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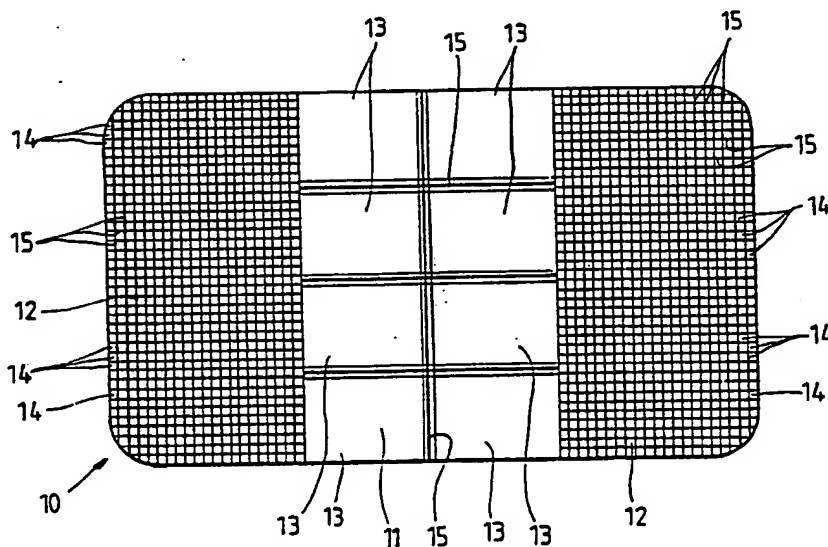
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(54) Title: SUSCEPTORS HAVING DISRUPTED REGIONS FOR DIFFERENTIAL HEATING IN A MICROWAVE OVEN



(57) Abstract

A packaging system is disclosed which includes a susceptor heating means having selective responsiveness to microwave radiation. The susceptor surface has a plurality of regions, where at least one region has an altered responsiveness to microwave radiation which is achieved by disruptions in the susceptor surface. A method for making regions of a susceptor selectively responsive to microwave heating by disrupting the continuity of the metallized film of the susceptor is also disclosed.

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5                   SUSCEPTORS HAVING DISRUPTED REGIONS FOR  
                  DIFFERENTIAL HEATING IN A MICROWAVE OVEN

10           In the past, difficulties have been experienced in  
          various attempts to brown or crisp foods in a microwave  
          oven. A microwave oven heats foods differently from a  
          conventional oven. Generally speaking, food substances  
          are heated in proportion to their tendency to absorb  
15   microwave radiation, which may result in considerably  
          different heating patterns from those which exist in a  
          conventional oven. Also, microwave radiation penetrates  
          into most foods in a way which results in considerably  
          different heating patterns from those which would other-  
20   wise be present in a conventional oven. In most cases,  
          microwave energy will heat foods faster than in a conven-  
          tional oven. For example, a food substance which might  
          require 30 minutes to properly "cook" in a conventional  
          oven, may take only 3 or 4 minutes to "cook" in a micro-  
25   wave oven. In a conventional oven, the oven atmosphere is  
          heated to relatively high temperatures to transfer heat to  
          the food surface resulting in the surface always being the  
          hottest area in the food. In a microwave oven, the oven  
          atmosphere is generally not heated; the food itself heats  
30   and transfers heat to the surrounding air resulting in the

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food surface being cooler than the interior. These differences significantly affect one's ability to brown or crisp a surface of a food in a microwave oven.

5        Many attempts have been made to brown or crisp the surface of a food in a microwave oven. One such attempt has involved the use of packaging components called  
10        susceptors. Suitable susceptors may contain microwave absorbing coatings which are deposited upon a microwave transparent support layer. These susceptors heat when  
15        exposed to microwave radiation. A susceptor may achieve temperatures high enough to brown or crisp the surface of a number of food products. The susceptor may be placed in close proximity to, or in direct contact with, the  
20        surface of the food product. A typical, commercially available susceptor contains a thin film of vacuum deposited aluminum on polyester which is then adhesively laminated to paper or board.

25        The use of susceptors, however, has resulted in additional problems. Available susceptors typically do not heat uniformly. As a result, such susceptors may not crisp or brown the food substance uniformly. For example, the outer region of a susceptor may become much  
30        hotter during microwave irradiation as compared to the center region of the susceptor. As a result, the outer portion of the food substance may tend to become brown or crisp, but the center portion will not do so without overcooking the outer portion. This is a particular problem  
35        in food substances which have large surface areas, for example, the baked crust of a large frozen pizza. When a susceptor pad is used, for example, to crisp several fish sticks arranged side by side on the susceptor, microwave heating may typically result in fish sticks on the ends of the susceptor which are crisp, but fish sticks in

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the center of the susceptor pad may not be adequately crisp.

An additional problem of heating foods using susceptor  
5   tors is the lack of control of the heating profile across  
the susceptor surface. It is often desirable to adjust  
the amount of heat output in sections of a susceptor to  
accommodate different food characteristics. This is a  
particular problem when two or more foods with varying  
10   browning/crisping requirements are placed in conjunction  
with a common susceptor. When heated, one food's contact  
surface may become overcooked while an adjacent food's  
contact surface may remain soggy.

15       When a food substance is cooked by microwave radiation,  
particular attention must be paid to the overall  
energy balance achieved during the heating process. If an  
attempt is made to simply increase the strength of the  
microwave radiation or cooking time in an effort to brown  
20   or crisp a particular area of the surface of the food  
substance, this may result in overheating or overcooking  
of other surfaces and/or the interior of the food  
substance itself. In other words, if one seeks to achieve  
browning or crisping of the center area of a pizza crust  
25   by simply increasing the heating time or by increasing the  
strength of the microwave radiation, the likely result  
would be an overcooking of the outer surface of the pizza  
and/or an overcooking of the pizza toppings.

30       Heating foods in a microwave oven, particularly where  
susceptors are employed, usually involves a complex  
balancing of energy which is absorbed throughout the food  
substance. Although the use of susceptors has resulted in  
some improvement in the browning or crisping of food  
35   substances in a microwave oven, the need has existed for  
solving the problem of susceptors which do not heat

uniformly. Some means for browning or crispening food products uniformly with a susceptor has been needed. The need has further existed for some means to achieve uniform browning and crispening without disturbing the complex  
5 energy balance necessary to properly heat all portions of the food substance. Also, the need has existed to differentially brown or crisp various types of food products.

Examples of attempts to achieve crispening of food  
10 products is shown in U.S. Patent No. 4,267,420, issued to Brastad, and U.S. Patent No. 4,230,924, issued to Brastad et al. Brastad attempted to produce flexible wrapping material which was wrapped completely around a fish stick to brown the surface of the fish stick. However, Brastad  
15 did not address the problem of nonuniform crispening of the food surface. Brastad did not disclose how to compensate for nonuniform heating caused by the flexible wrapping material.

20 Another example is U.S. Patent 4,641,005, issued to Oscar E. Seiferth. A thin film susceptor is disclosed for heating foods. However, Seiferth did not address the problem of nonuniform heating of the susceptor surface. Seiferth did not disclose how to compensate for food loads  
25 or how to compensate for susceptor preferential edge heating.

It will be apparent from the above discussion that prior art attempts to achieve crispening of the surface of  
30 a food substance in a microwave oven have not been altogether satisfactory. The use of susceptors has often resulted in nonuniform crispening of the food surface and undesirable nonuniform heating patterns.

35 In accordance with the present invention, a system for heating a food substance in a microwave oven is



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provided which may be used to achieve more uniform heating of the surface of a food substance. The system includes susceptor means which comprises variable sized conductive areas. The size of the conductive areas is adjusted to  
5 compensate for undesirable nonuniform heating patterns which would otherwise exist.

The susceptor means is located in close proximity to, or in direct contact with, the surface of the food  
10 substance which is to be crispened or browned. The susceptor means generally comprises a sheet with a conductive coating, typically a metallized film, which absorbs microwave energy during exposure to microwave fields. The susceptor means therefore heats in response to microwave  
15 radiation. In accordance with the present invention, the conductive coating is divided into a plurality of regions having susceptor areas which may be of a different size in each region. The susceptor areas may be formed, for example, by scoring, cutting, etching, stamping, printing,  
20 or other methods to disrupt the conductive coating of the susceptor means. At least one region has its responsiveness to the heating effects of microwave radiation altered by the disruptions in the conductive coating.

25 Portions of the susceptor which would otherwise tend to overheat may be provided with small susceptor areas which are comparably less responsive to microwave radiation. Portions of the susceptor means which would otherwise tend to underheat are provided with larger susceptor  
30 areas which are comparably more responsive to microwave radiation. By adjusting the size of the susceptor areas within the limits of this invention, it is possible to compensate for nonuniform heating patterns which might otherwise exist on a susceptor. More uniform crispening  
35 and browning of a food substance may thereby be achieved. Alternatively, when a nonuniform crispening or browning

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pattern is desired, a susceptor means may be designed in accordance with the present invention to provide a specific desired heating pattern.

5 For a fuller understanding of the present invention, reference should be had to the following detailed description taken in conjunction with the drawings, in which:

FIG. 1 is a top view of a susceptor pad having two  
10 regions, each being provided with different sizes of susceptor areas formed thereon.

FIG. 2 is a graph showing the heating profile of a  
susceptor pad that was not constructed in accordance with  
15 the present invention.

FIG. 3 is a graph showing the temperature profile of  
a similar susceptor pad, but which used regions with  
different sized susceptor areas in accordance with the  
20 present invention.

FIG. 4 is a bar graph illustrating the effect of  
different sized susceptor areas formed in accordance with  
the present invention on crisping.  
25

FIG. 5 is an image of a temperature pattern achieved  
during microwave irradiation of a susceptor that did not  
have variable sized susceptor areas in accordance with the  
present invention. The image was created by an infrared  
30 camera.

FIG. 6 is a similar image of the heating pattern of a  
susceptor which had variable sized susceptor areas in  
accordance with the present invention.  
35

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FIG. 7 is a top view of a susceptor having variable susceptor areas in accordance with the present invention for use in crisping the surface of food products such as pizza.

5

FIG. 8 is a graph representing the temperature profile of a round pizza susceptor which did not have graduated sized areas in accordance with the present invention.

10

FIG. 9 is a graph showing a temperature profile of a similar susceptor, but which did have graduated sized susceptor areas as shown in FIG. 7.

15

FIG. 10 is a bar chart illustrating the effect of variable sized susceptor areas using a susceptor pad constructed in accordance with FIG. 7 on browning.

20

FIG. 11 is an image of the heating pattern of a susceptor constructed in accordance with FIG. 7. The image was created with an infrared camera.

25

FIG. 12 is a graph depicting the temperature reached during microwave heating as a function of the size of the susceptor areas.

30

FIG. 13 is a graph showing the percent power absorbed, transmitted, and reflected as a function of the size of the susceptor areas.

35

FIG. 14 is a graph of capacitance reactance as a function of the size of the susceptor areas.

FIG. 15 is a top view of an alternative embodiment of a susceptor utilizing a maze pattern to decrease the

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microwave heating effect upon a disrupted region of the  
susceptor.

FIG. 16 is a top view of a susceptor demonstrating  
5 the effect upon microwave heating by disruption of the  
conductive sheet without cutting.

FIG. 17 is an infrared image of the microwave heating  
effects upon a susceptor without any disruptions.

10

FIG. 18 is an infrared image of the microwave heating  
effects upon the susceptor illustrated in FIG. 16.

FIG. 19 is a top view of a susceptor having four  
15 different regions of responsiveness formed using the  
present invention.

FIG. 20 is a graph depicting the temperature profile  
during microwave heating of the susceptor constructed in  
20 accordance with FIG. 19.

FIG. 21 is a top view of a susceptor using the  
principle of "directed flow."

25 FIG. 22 is an infrared picture of the microwave  
heating effects upon a susceptor without being modified,  
which was used as a control example for comparison.

FIG. 23 is an infrared picture depicting microwave  
30 heating of a susceptor constructed in accordance with FIG.  
21.

FIG. 24 is a top view of a susceptor constructed in  
accordance with FIG. 21, and subsequently modified with  
35 additional cuts to disrupt electrical conductivity between  
the center region and the strips of susceptor.

FIG. 25 is an infrared image depicting microwave heating of the susceptor constructed in accordance with FIG. 24.

5        FIG. 26 is a top view of an example of a susceptor utilizing the principle of "directed flow."

FIG. 27 is a top view of a susceptor constructed in accordance with the present invention having a spiral cut  
10        therein to achieve "directed flow."

FIG. 28 is a top view of a susceptor constructed in accordance with the present invention having a square spiral cut in order to achieve "directed flow."

15

FIG. 29 is a top view of an alternative embodiment of a round susceptor using "directed flow."

In order to crispen the surface of a food substance,  
20        a susceptor pad 10 may be used. The food substance which is to be crispened may be placed in close proximity to, or in direct contact with, the susceptor pad 10. The susceptor pad 10 may include a layer of metallized polyester, composed of a layer of polyester which has a thin film of  
25        metal such as aluminum deposited thereon. The layer of polyester serves as a support for the thin film of metal. The conductive layer of metal may be deposited on the polyester substrate by a process of vacuum vapor deposition. The metallized polyester layer is preferably  
30        adhesively bonded to a supporting face, such as paper.

For a disclosure of the details of a suitable composition for the susceptor pad 10, reference is made to application Serial No. 070,293, filed July 6, 1987, by  
35        Michael R. Perry et al., entitled "Package for Crisping the Surface of Food Products in a Microwave Oven", the

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entire disclosure of which is incorporated herein by reference. Further disclosure of a susceptor pad is contained in U.S. Patent No. 4,641,005, issued to Oscar E. Seiferth, entitled "Food Receptacle for Microwave Cooking", the entire disclosure of which is incorporated herein by reference.

It has been found that if a susceptor pad having a continuous metallized layer is exposed to microwave radiation, an uneven heating pattern will typically result as shown in FIG. 5. The heating effects often will be most pronounced at the edges of the susceptor pad, while the center may not be adequately heated. When such a susceptor pad is used, for example, to crisp a plurality of fish sticks arranged side by side on the susceptor pad, microwave irradiation may typically result in fish sticks on the ends which are crisp, but fish sticks in the center of the susceptor pad may not be adequately crisp. At least the fish sticks will not be uniformly crispened.

It is desirable to have some means to compensate for the nonuniform heating which may result when a susceptor pad is exposed to microwave radiation. In accordance with the present invention, variable sized susceptor areas are provided which compensate for the otherwise undesirable nonuniform heating characteristics of a susceptor pad. As illustrated in FIG. 1, susceptor pad 10 is provided with larger sized susceptor areas in center region 11 and relatively smaller sized susceptor areas in end regions 12. The relatively more microwave responsive center region 11 contains larger susceptor areas 13. The less microwave responsive end regions 12 contain relatively small susceptor areas 14.

In this illustrated example, the conductivity of the metallized film is broken by cuts or scores 15. The

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scores 15 may be cuts in the metallized layer made by a sharp implement such as a razor blade. Or the scores 15 may be formed by stamping a sharp die on the susceptor pad 10. Any means for forming disruptions or conductivity breaks between the metallized layer of one susceptor area 13 and an adjacent susceptor area 13 should provide satisfactory results. For example, conductivity breaks may be formed by etching, scoring, cutting, stamping, or photo resist methods. It has been surprisingly found that it is only necessary to disrupt the metallized layer, which can be sometimes done by drawing a line with a ball point pen across the surface of the susceptor pad 10. Generally, any procedure which disrupts electrical continuity in the thin film of metal has been found to be effective. The scores 15 similarly form conductivity breaks in the metallized film between a small susceptor area 14 and an adjacent small susceptor area 14.

The smaller susceptor areas 14 are formed sufficiently small so that the susceptor areas 14 are less responsive to microwave radiation than the larger susceptor areas 13. Thus, when the susceptor pad 10 is exposed to microwave radiation, the smaller susceptor areas 14 will be less responsive to the heating effects of the microwave radiation than would be the case if the scoring 15 was not provided on the susceptor pad 10. The smaller susceptor areas 14, in effect, "detune" the responsiveness of the end region 12 to microwave radiation.

The larger susceptor areas 13 are comparatively more responsive to heating effects of microwave radiation. The larger susceptor areas 13 are believed to have less of a "detuning" effect upon the center region 11. The larger susceptor areas 13 also improve the uniformity of heating of the center region 11. Without having the susceptor areas 13 cut in the center region 11, some edge heating of

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the center region 11 could occur in this example. The  
susceptor areas 13 may be formed so that no "detuning"  
effect is achieved. In some applications, it is only  
important that the relative heating of one region 12 be  
5 less than another region 11.

The configuration of the small susceptor areas 14 and  
the larger susceptor areas 13 illustrated in FIG. 1 tends  
to compensate for the tendency of the end regions 12 to  
10 overheat as compared with the center region 11.

FIG. 2 illustrates the heating profile of a susceptor  
pad used to heat fish sticks in a microwave oven. FIG. 2  
involves a susceptor pad which did not have variable sized  
15 susceptor areas 13 and 14. The temperature of various  
positions on the horizontal center line of the susceptor  
pad were measured using an infrared camera. Line 16  
represents the temperature profile of a susceptor pad  
after exposure to microwave radiation for 30 seconds.  
20 Line 17 represents the temperature profile of the same  
susceptor pad after exposure to microwave radiation for 60  
seconds. Line 18 represents the temperature profile of  
the same susceptor pad after exposure to microwave  
radiation for 210 seconds.

25 As shown in FIG. 2, the temperature of the center of  
the susceptor pad quickly heated to a relatively high  
temperature within 30 seconds, and then dropped by the  
time that the 60 seconds temperatures were measured. The  
30 temperature of the center of the susceptor pad remained  
low through 210 seconds of microwave irradiation, as shown  
by line 18. However, the edges of the susceptor pad  
remained at relatively high temperatures. The result was  
that fish sticks at the end regions of the susceptor pad  
35 were more crisp than fish sticks located in the center  
region of the susceptor pad. Nonuniform crispening of the



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fish sticks was observed. The total cooking time for the fish sticks was approximately 3-1/2 to 4 minutes.

The temperatures were measured with an infrared camera. The temperatures are "uncorrected" because the infrared camera was aimed through a wire mesh shield. The wire mesh shield was used to prevent leakage of microwave energy from the microwave oven. The wire mesh probably resulted in lower average temperature readings on the infrared camera. However, here the relative temperature differences are of primary interest. Thus, although the actual temperatures measured may not be precisely accurate, the relative temperatures are believed to be accurately portrayed.

15

FIG. 3 represents temperature profiles of a susceptor pad 10 constructed in accordance with FIG. 1. As shown in FIG. 3, the relative heating of the center region 11 as compared with the end regions 12 was effected by the use of smaller susceptor areas 14 on the end regions 12.

Line 19 represents the temperature profile of the susceptor pad 10 after 30 seconds of exposure to microwave radiation. Line 20 represents the temperature profile of the susceptor pad 10 after exposure to microwave radiation for 60 seconds. Line 21 represents the temperature profile after exposure to microwave radiation for 210 seconds. The temperature of the end regions 12 remained relatively low at the 30 seconds measurement represented by line 19, and at the 60 seconds measurement represented by line 20. The temperature of the end regions 12 did rise toward the end of the heating period, as shown by line 21.

FIG. 4 is a graph representing the effect of the smaller susceptor areas 14 on the end regions 12 and the

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larger susceptor areas 13 in the center region 11 upon the crispness of fish sticks. A plurality of fish sticks was arranged on the susceptor pad 10 illustrated in FIG. 1. The fish sticks were placed parallel to each other in side-by-side relationship. The length of the fish sticks was oriented vertically in FIG. 1. In other words, the length of the fish sticks was oriented in the same direction as the width of the susceptor pad 10. Thus, some fish sticks lay entirely in contact with the end regions 12, while other fish sticks lay in contact entirely with the center region 11.

In a test using a trained sensory panel, fish sticks in contact with the center region 11 averaged about a 10% change (increase) in breading crispness, as shown by bar graph 22 in FIG. 4. Fish sticks prepared on standard susceptors and on scored susceptors were compared by the panel. Fish sticks in contact with the end regions 12 of the susceptor pad 10 experienced a -11% change (decrease) in breading crispness, as shown by bar graph 23 in FIG. 4. The percentage changes were based upon a comparison with fish sticks cooked on a susceptor pad which did not contain variable susceptor areas 13 and 14. Thus, the use of variable susceptor areas 13 and 14 resulted in an increase in the crispness of fish sticks on the center region 11, and a decrease in the crispness of fish sticks on the end regions 12. The variable sized susceptor areas 13 and 14 therefore compensated for nonuniform heating which would have otherwise resulted during microwave irradiation of the combination of the susceptor pad and fish sticks.

The effect of the variable sized susceptor areas 13 and 14 is further illustrated by a comparison of FIG. 5 with FIG. 6. FIG. 5 represents an image taken with an infrared camera during microwave irradiation of a susceptor pad which did not include variable sized susceptor

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areas 13 and 14. FIG. 6 illustrates the temperature profile of a susceptor constructed in accordance with FIG. 1. The infrared image of FIG. 6 was taken after 30 seconds of exposure to microwave radiation. FIG. 6 corresponds with the 30 second temperature profile shown in FIG. 3 (represented by line 19). FIG. 6 shows that the microwave heating of the end regions 12 was greatly reduced as compared with the center region 11.

10 In the susceptor pad 10 illustrated in FIG. 1, the small susceptor areas 14 are formed in the shape of squares which are approximately 1/16 inch on each side. In other words, the small susceptor areas 14 are formed in the shape of squares having a height and width of 0.0625  
15 inch.

The large susceptor areas 13 in the center region 11 of the susceptor pad 10 illustrated in FIG. 1 are formed in the shape of rectangles having a length of 1-1/4 inches and a width of 7/8 inch. In other words, the large  
20 susceptor areas 13 have a length of 1.25 inches and a width of 0.875 inch.

The overall length of the illustrated susceptor pad  
25 10 was 6-1/2 inches. The overall width was 3-3/4 inches. Each end region 12 was about 2 inches by 3-3/4 inches. The center region 11 was about 2-1/2 inches by 3-3/4 inches. The scores 15 used for separating the small and large susceptor areas 14 from each other and from adjacent  
30 large susceptor areas 13 were the width of a razor blade cut in the metallized polyester layer.

FIG. 7 illustrates a round susceptor pad 24 used for browning the crust of a pizza or the like. In the case of  
35 a round susceptor for use in heating pizza, it has been found that the outer perimeter of the susceptor pad tends

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to heat much more than the center region of the susceptor pad. This often results in a browning of the outer surface area of the pizza crust, while only 50-60% of the center area of the pizza crust is browned. This is shown  
5 by the information depicted in FIG. 8 and FIG. 10, which will be explained in more detail below.

It is desirable to have some means for reducing the heating of the outer region 26 of the susceptor pad 24,  
10 while increasing the relative heating of the center region 25 of the susceptor pad 24. In the present invention, this is accomplished by providing conductivity breaks or scoring 27 in the outer region 26 of the susceptor pad 24. The scores 27 may be in the form of cuts made with a razor  
15 blade or the like. It is sufficient if the scores 27 are made in any manner which disrupts or breaks the electrical conductivity of the metallized layer of the susceptor pads 24.

20 The scores 27 define small susceptor areas 28 in the outer region 26 of the susceptor pad 24. The center region 25 defines a larger susceptor area 29. The small susceptor areas 28 are less responsive to the heating effects of microwave radiation, as compared with the large  
25 susceptor area 29. This has the effect of reducing the level of heating in the outer region 26 of the susceptor pad 24, where the susceptor 24 would otherwise tend to overheat. The provision of variable susceptor areas 26 and 29 has the effect of increasing the temperature of the  
30 center region 25 relative to the outer region 26.

FIG. 8 is a graph illustrating temperature profiles of a round susceptor pad used for browning the crust of a pizza. Line 30 represents temperature measurements at  
35 various horizontal positions of the susceptor pad after 30 seconds of exposure to microwave radiation. Line 31

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represents temperature measurements at the same locations after exposure to microwave radiation for 120 seconds.

Line 32 represents temperature measurements after exposure to microwave radiation for 300 seconds. Line 33 depicts

- 5 temperature measurements after 390 seconds of exposure to microwave radiation. FIG. 8 shows that the outer portion of the susceptor pad became much hotter than the center portion of the susceptor pad.

- 10 FIG. 9 illustrates the temperature profile of a susceptor pad 24 constructed in accordance with the embodiment illustrated in FIG. 7. Line 34 shows temperature measurements at various horizontal positions on the susceptor pad 24 after exposure to microwave radiation for
- 15 30 seconds. Line 35 depicts temperature measurements after 120 seconds of exposure to microwave radiation. Line 36 shows temperature measurements after 300 seconds of exposure. Line 37 depicts temperature measurements taken after 390 seconds of exposure to microwave
- 20 radiation.

- A comparison of FIG. 9 with FIG. 8 shows that the use of variable susceptor areas 28 and 29 dramatically change the temperature profile of the pizza susceptor 24. The
- 25 center region 25 became much hotter after 390 seconds of exposure, than did the center region of a susceptor pad which was not constructed in accordance with the present invention. The temperature of the outer region 26 was reduced, while the temperature of the center region 25 was
- 30 increased.

- FIG. 10 is a bar chart illustrating the effect upon browning of the pizza crust as a result of the use of different sized susceptor areas 28 and 29 on the susceptor
- 35 pad 24. The bar chart represents the percentage of crust area which was browned after microwave heating.

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Bar 38 in FIG. 10 represents the percentage of crust area which was browned using a susceptor pad that did not have different sized susceptor areas. Slightly less than 80% of the pizza crust area was browned in this instance.

5 More than about 85% of the area of the outside of the pizza crust was browned, as shown by bar 40 in the bar chart of FIG. 10. However, less than 60% of the center area of the pizza crust was browned, as shown by bar 39 in FIG. 10.

10

Using a susceptor pad 24 having different sized susceptor areas 28 and 29, as shown in FIG. 7, the amount of browning which occurred in the center region 25 was greatly increased, while the amount of browning which

15 occurred in the outer region 26 was greatly decreased. Bar 42 represents the amount of browning which occurred in the center region 25. About 95% of the area of the crust in the center region 25 was browned in this instance.

Only about 5% of the area of the crust in the outer region  
20 26 was browned, as shown by bar 43 in FIG. 10. The total percentage of the area of the crust which was browned was less than 30%, as shown by bar 41 in FIG. 10.

FIG. 11 is an image taken with an infrared camera  
25 depicting the heating pattern of a susceptor pad 24 constructed in accordance with the embodiment illustrated in FIG. 7. The infrared image was taken at a point during the heating period corresponding to three hundred ninety seconds of exposure to microwave radiation. The infrared  
30 image of FIG. 11 corresponds with line 37 depicted in the temperature profile graph of FIG. 9. The areas corresponding to the center region 25 and the outer region 26 are marked in FIG. 11.

35 In the particular susceptor pad 24 illustrated in FIG. 7, the diameter of the susceptor 24 was nine inches.

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The diameter of the center region 25 was about 4.5 inches. The small susceptor areas 28 were formed generally as squares having a height and width of about 1/16 inch, or 0.0625 inches. The scores 27 were formed by razor blade cuts in the metallized layer of the susceptor pad 24.

When one region 26 of a susceptor 24 is made less responsive to microwave heating, the amount of heating of a nondisrupted region 25 may be increased. This phenomenon is referred to as "load sharing." It is believed that when one region 26 is made less responsive to microwave heating, there is more energy available to heat other regions 25.

FIG. 12 is a graph depicting the heating effect of small susceptor areas 14 as a function of the size of the area. In this case, the susceptor areas were formed as squares. The indicated dimensions are the height and width of the squares.

FIG. 12 shows that the responsiveness of small susceptor areas 14 to the heating effects of microwave radiation rapidly decreases when the squares 14 are made smaller than 0.625 inches on a side where the metallized susceptor pad 10 has a relatively large resistivity of 1650 ohms per square. For lower resistivities on the order of eighteen ohms per square, the responsiveness of the small squares 14 to the heating effects of microwave radiation decreases when the squares are made smaller than 0.3125 inches on each side.

In FIG. 12, line 44 depicts the temperature as a function of size for small squares 14 where the resistivity of the metallized layer of the susceptor pad 10 is eighteen ohms per square. Line 45 depicts the temperature as a function of size of squares 14 where the resistivity

-20-

of the metallized layer of the susceptor pad 10 was sixty ohms per square. Line 46 depicts the temperature as a function of size for susceptor areas 14 where the resistivity of the metallized layer was 1650 ohms per square.

5 These temperatures have not been corrected for the differences in emissivity of the susceptor surface. The relative temperatures along each line (44, 45, 56) are correct. The comparative heating between susceptors of different resistivities is affected by emissivity

10 differences of the susceptor surfaces and has not been corrected in FIG. 12.

FIG. 13 depicts data taken with a network analyzer for the susceptor pad 10 which was 60 ohms per square, and

15 which formed the basis for the measurements depicted in FIG. 12 by line 45. A 5-inch square uncut susceptor pad 10 provided reflectance, transmission and absorption measurements which are shown on the far right-hand portion of the graph of FIG. 13. For the uncut pad, the absorption

20 tion was measured at about 30%. The reflection was measured at about 68%. The transmission was measured at about 2%.

FIG. 13 shows that the reflection, transmission and

25 absorption of a susceptor pad 10 are affected by disruptions or conductivity breaks in the susceptor surface. The curves begin to change significantly when the size of the squares 14 created by the disruptions or breaks in conductivity were made 0.625 inch on a side, or smaller.

30 The percentage power absorbed decreased significantly for squares which were 0.625 inch on a side, or smaller. An absorption of about 33% was measured for squares 14 having a width of 0.625 inch. An absorption of about 27% was measured for squares 14 having a width of about 0.3125

35 inch. An absorption of about 20% was measured for squares 14 having a width of about 0.1563 inch. An absorption of



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about 11% was measured for squares 14 having a width of about 0.0781 inch.

All measurements were taken by the network analyzer  
5 prior to heating of the susceptor pad 10 in a microwave oven. This technique, i.e., using network analyzer data, may be used to determine the reduced responsiveness of susceptor pad regions which have disruptions or conductivity breaks that form complex patterns which may not define  
10 simple squares 14 as depicted in the above examples. Thus, it should be appreciated that reduced responsiveness to microwave heating can be achieved using disruption patterns or conductivity breaks of various configurations, in addition to the illustrated example of squares 14.

15

The effect of disruptions or conductivity breaks in the susceptor surface may be better understood with respect to FIG. 14. FIG. 14 is a graph depicting the effect upon the reactive component of the impedance of a  
20 susceptor pad when small squares 14 are formed in the susceptor surface. The data plotted on FIG. 14 was measured with a network analyzer, using the same susceptor pad which had an initial resistivity of 60 ohms per square. More specifically, the impedance of the susceptor  
25 pad was essentially all resistive prior to cutting, as shown by the point at the upper right-hand corner of the graph, measured for the uncut 5-inch square susceptor pad.

Conductivity breaks in the surface of the susceptor  
30 pad created a negative reactance, i.e., a capacitive reactance. The total impedance  $Z_s$  of the susceptor pad may be expressed as:

-22-

$$Z_s = R_s - jX_s$$

where  $R_s$  is the resistance component of the impedance, and  $X_s$  is the reactance component of the impedance. If  $X_s$  is positive, then the reactance is inductive. If  $X_s$  is negative, then the reactive component is capacitive. When the surface of the susceptor is discontinuous, as a result of disruptions or breaks in the conductivity of the susceptor pad surface, the susceptor typically demonstrates a capacitive reactance.

Measuring the reactance of the susceptor surface provides an indication of the magnitude of the discontinuity or disruption of a region of the susceptor surface. This is proportional to the extent to which the responsiveness of that region to heating during microwave irradiation will be affected by the discontinuity or disruption in the susceptor pad surface.

The relative difference in the capacitive reactance of various regions of the susceptor pad resulting from disruptions in the susceptor surface may be used as a means of determining whether one region will be less responsive to the heating effects of microwave radiation as compared to another region of the susceptor pad. Thus, complex patterns may be used to create disruptions in the susceptor pad surface. Measurements with the network analyzer may be used for determining the changed responsiveness of a region of the susceptor pad to the heating effects of microwave radiation as a result of any complex pattern of disruptions.

FIG. 15 illustrates an embodiment of a susceptor pad surface having a complex "maze" pattern forming disruptions in the susceptor pad surface. For complex patterns such as shown in FIG. 15, network analyzer measurements

-23-

may be used for determining the relative responsiveness of various regions to microwave radiation.

FIG. 15 shows a first region 47 of the susceptor pad having discontinuities or disruptions in the form of a maze pattern. The disruptions in the first region 47 render it less responsive to the heating effects of microwave radiation than would be the case if the disruptions in the susceptor surface were not present in the first region 47. A second region 48 is also shown, in this example as a center rectangle of susceptor material.

Disruptions in the susceptor surface do not necessarily have to take the form of cuts in the surface. The susceptor surface may be disrupted, for example, by drawing lines using a ball point pen. An example of the ability to achieve less responsiveness by disruptions created, for example, with a ball point pen, is shown in the experiment illustrated in FIG. 16. A square susceptor pad 49 was used in this experiment. A grid pattern covering a first region 50 was drawn on the susceptor pad 49 using a ball point pen. Three circular regions 51 were arbitrarily selected, and were not provided with disruptions. The relative heating of two susceptor pads is shown in FIGS. 17 and 18, without the grid pattern and with the grid pattern illustrated in FIG. 16, respectively.

FIG. 17 shows an image formed with an infrared camera showing the heating effects upon a susceptor pad without any disruptions. This susceptor pad was used as a control for the experiment.

FIG. 18 is an infrared image of the heating effect upon a susceptor pad 49 having a grid pattern drawn on it using a ball point pen. The relative difference in the

-24-

heating of the three circular regions 51 which did not have the susceptor pad surface disrupted is clearly apparent from the infrared image of FIG. 18. This experiment demonstrated the effectiveness of disruptions in affecting the heating response of a region of a susceptor pad. Thus, actual cuts in the susceptor pad surface are not required. Disruptions may be created by pressing or stamping the susceptor pad surface. Disruptions may be created which are virtually invisible. However, the effect of disruptions can be revealed by measurements taken using a network analyzer.

FIG. 19 shows a susceptor pad 52 which has a first region 53, a second region 54, a third region 55 and a fourth region 56, each having different patterns of conductivity breaks in the surface of the susceptor pad 52. In this example, squares 57 were formed in the fourth region 56. The squares 57 had a width of  $1/2$  inch. The squares 57 were formed by making cuts 61 in the surface of the susceptor pad 52 using a razor blade.

The third region 55 had smaller squares 58 formed by cuts 61, which had a width of about  $1/4$  inch. The second region 54 had even smaller squares formed therein which had a width of about  $1/8$  inch. The first region 53 had the smallest squares 60 formed by cuts 61, which had a width of about  $1/16$  inch.

FIG. 20 illustrates the temperature profile of the susceptor pad 52 constructed in accordance with FIG. 19. The heating effects of the microwave radiation on the fourth region 56 was much greater than the heating effects upon the other regions 53, 54 and 55. The smaller the size of the squares in the region, the less heating was observed. Temperatures were measured using an infrared camera.

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Cuts or disruptions in the surface of the susceptor may be used to create an effect which may be referred to as "directed flow." This may be illustrated with reference to the experiment depicted in FIGS. 21-25.

5

FIG. 21 illustrates a susceptor pad 62. Parallel cuts 63 were made in the surface of the susceptor pad 62. A center uncut region 64 was left in the middle of the susceptor pad 62. The parallel cuts 63 defined strips 65  
10 on the surface of the susceptor pad 62. There was no conductivity break or disruption between the end of each strip 65 and the center region 64 of the susceptor 62.

FIG. 22 is an image taken with an infrared camera  
15 showing the heating pattern of an uncut susceptor. This was used as a control for the experiment. FIG. 23 is an image taken with an infrared camera showing the heating pattern of the susceptor 62 constructed in accordance with FIG. 21. Intense heating of the center region 64 is  
20 apparent. The strips 65, which are connected without disruption to the center region 64, appear to enhance heating of the center region 64.

FIG. 24 shows a susceptor pad 66 constructed in  
25 accordance with FIG. 21, with the exception that additional cuts 67 were made to disrupt or break the continuity between the strips 65 and the center region 64. FIG. 25 is an image taken with an infrared camera showing the heating pattern of the susceptor pad 66 constructed in  
30 accordance with FIG. 24. The heating of the center region 64 is not as pronounced as in the example shown in FIG. 21.

FIG. 26 illustrates an alternative embodiment of a  
35 susceptor pad 68 utilizing the principle of "directed flow." In this example, the susceptor pad 68 was a

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circular susceptor, for example, suitable for use with pizza and the like. The susceptor pad 68 illustrated in FIG. 26 has radial cuts or disruptions 69. The cuts 69 define strips 70 extending radially inwardly toward a center region or target area 71. The strips 70 are connected without disruption to the center region 71. It will be appreciated that the target area 71 may be located at a position other than the center of the susceptor 68.

Secondary cuts 72 may be provided to extend only partially toward the center region 71. A secondary region 73 is defined by the region extending radially outward from the center of the pad 68 to the ends of the secondary cuts 72. This results in a relatively hot center region 71. The secondary region 73 will be generally warmer than the outermost region 74 of the susceptor pad 68.

Generally, the more cuts 69 which are provided in the susceptor pad 68, the hotter the center region 71 will be. It has also been observed in practice that the uniformity of the heating of the outermost region 74 of the susceptor pad 68 is improved by providing an increased number of cuts 69 in the susceptor pad 68.

A circular cut could be made around the center region 71 to break electrical conductivity between the center region 71 and the strips 70. The center region 71, in such an example, has been observed to get preferentially hot during microwave heating, but not as hot as compared to an example where the center region 71 is connected to the strips 70 without disruption, as shown in FIG. 26.

An alternative embodiment of a round susceptor 75 is shown in FIG. 29. The illustrated example has a plurality of cuts 76 extending from the outer perimeter radially inwardly toward a center region 77. The cuts 76 define a

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plurality of strips 78 extending radially from the center region 77. In this case, all of the cuts 76 extend from the perimeter of the susceptor 75 to the edge of the center region 77. All other things being equal, the center region 77 of the example illustrated in FIG. 29 would get hotter than the center region 71 of the example illustrated in FIG. 26.

A variety of geometries have been used to demonstrate the principle of "directed flow." For example, round spirals, as shown in FIG. 27, squared spirals, as shown in FIG. 28, pinwheel-shaped cuts, cross-shaped regions, etc. have been tried. All of these various geometries demonstrate the ability to generate a relatively hot center region which is connected without disruption to various shaped strips.

The center region generally has been observed to have a maximum size at which the principle of "directed flow" will work most effectively. If the area of the center region is made too large, the center region will not get as hot. The maximum size of the center region is believed to be a function of the resistivity of the susceptor pad material. The lower the resistivity, the larger the center region may be and still effectively result in pronounced heating of the center region. Generally speaking, the smaller the center region the hotter or more intense will be the heating effect on the center region.

A susceptor may be constructed where the susceptor surface is initially constructed having disruptions or breaks in the conductive layer. Additional disclosure is contained in an application entitled "Microwave Heater and Method of Manufacture", by Turpin et al., filed contemporaneously herewith, the entire disclosure of which is incorporated herein by reference.

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In the above description, measurements of resistivity, reflectance, transmission, absorbance, etc., were all taken at room temperature (21° C) unless otherwise specified.

5

In the above descriptions, measurements taken with a network analyzer all involved the procedure described below. A Hewlett Packard Model No. 8753A network analyzer in combination with a Hewlett Packard Model No. 85046A S-parameter test set were used. All measurements were made at the microwave oven operating frequency of 2.45 GHz. All measurements were made at room temperature, unless otherwise specified. All measurements are made using WR-282 waveguide. Measurements of reflectance, transmission and absorption were made without the presence of a food item.

Measurements are preferably made by placing a sample to be measured between two adjoining pieces of waveguide. Conductive silver paint is preferably placed around the outer edges of a sample sheet which is cut slightly larger than the cross-sectional opening of the waveguide. Colloidal silver paint made by Ted Pella, Inc. has given satisfactory results in practice. The sample is preferably cut so that it has an overlap of about 50/1000 inch (0.127 cm) around the edge. The waveguide is calibrated according to procedures specified and published by Hewlett Packard, the manufacturer of the network analyzer.

Scattering parameters,  $S_{11}$ ,  $S_{12}$ ,  $S_{21}$  and  $S_{22}$ , are measured directly by the network analyzer. These measured parameters are then used to calculate the microwave power reflectance, power transmittance, and power absorbance.

The reflectance looking into port 1 is the magnitude of  $S_{11}$  squared. The reflectance into port 2 is the magni-



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tude of  $S_{22}$  squared. The transmittance looking into port 1 is the magnitude of  $S_{21}$  squared. The transmittance looking into port 2 is the magnitude of  $S_{12}$  squared. The power absorbance, looking into either port 1 or port 2, is equal to one minus the sum of the power reflectance and the power transmittance into that port.

The complex surface impedance of an electrically thin sheet is obtained from the measured scattering parameters using formulas presented in "Properties of Thin Metal Films at Microwave Frequencies", by R. L. Ramey and T. S. Lewis, published in the Journal of Applied Physics, Vol. 39, No. 1, pp. 3883-84 (July 1968), along with the information in J. Altman, Microwave Circuits, pp. 370-71 (1964), both of which are incorporated herein by reference. For undisrupted susceptor material, the impedance is essentially all resistive. Disruptions or conductivity breaks introduce a capacitance reactance component into the impedance.

20

The infrared images and temperature measurements made with an infrared camera were taken using a Thermovision 870 scanner (infrared camera). The infrared camera was used in conjunction with a TIC-8000 Thermal Image Computer. Image analysis was accomplished using CATS software, (version 1.04). The infrared camera, computer and software are commercially available from Agema Infrared Systems A.B., with offices in Danderyd, Sweden.

The original infrared images of FIGS. 5, 6, 11, 17, 18, 22, 23 and 25 were in color. For convenience, black and white copies have been used herein. The color originals are not believed to be essential matter. However, the color originals are hereby incorporated herein by reference.

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The above disclosure has been directed to a preferred embodiment of the present invention. The invention may be embodied in a number of alternative embodiments other than those illustrated and described above. A person skilled  
5 in the art will be able to conceive of a number of modifications to the above described embodiments after having the benefit of the above disclosure and having the benefit of the teachings herein. The full scope of the invention shall be determined by a proper interpretation of the  
10 claims, and shall not be unnecessarily limited to the specific embodiments described above.

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## CLAIMS:

1. A packaging system including susceptor heating means  
5 having selective responsiveness to microwave radiation,  
comprising:

a susceptor for heating in response to microwave  
radiation, the susceptor being adapted to brown  
10 or crispen the surface of a food substance  
placed in close proximity thereto, the susceptor  
having a conductive film formed upon a support,  
the conductive film having a first region opera-  
tive to heat responsive to microwave radiation,  
15 the conductive film having a second region which  
is less responsive to microwave radiation than  
the first region, the second region and the  
first region being separated by a break in the  
conductive film, the second region comprising a  
20 region having conductivity breaks in the  
conductive film to reduce the responsiveness of  
the second region to heating due to microwave  
irradiation.

25

2. The packaging system according to claim 1, wherein:

the second region of the conductive film comprises  
small discrete conductive film areas defined by  
30 the conductivity breaks in the conductive film,  
the small discrete conductive film areas having  
dimensions small enough to reduce the  
responsiveness of the second region to heating  
by microwave irradiation relative to said first  
35 region.

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3. The packaging system according to claim 1, wherein:

the second region of the conductive film comprises a plurality of substantially square shaped conductive film areas, the square shaped conductive film areas being separated from each other by breaks in the conductive film.

4. The packaging system according to claim 3, wherein:

the square shaped conductive film areas in the second region have a length less than about 0.625 inches.

5. The packaging system according to claim 3, wherein:

the square shaped conductive film areas in the second region have a length less than about 0.3125 inches.

6. The packaging system according to claim 3, wherein:

the square shaped conductive film areas in the second region have a length less than about 0.1563 inches.

7. The packaging system according to claim 3, wherein:

the square shaped conductive film areas in the second region have a length less than about 0.0781 inches.

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8. The packaging system according to claim 1, wherein:  
the conductive film is a metallized layer of  
aluminum.
- 5
9. The packaging system according to claim 8, wherein:  
the metallized layer of aluminum has a resistivity  
between about 10 ohms per square and about 1700  
ohms per square.
- 10
10. The packaging system according to claim 8, wherein:  
the metallized layer of aluminum has a resistivity  
between about 60 ohms per square and about 1650  
ohms per square.
- 15
- 20
11. The packaging system according to claim 2, wherein:  
the conductive film is a metallized layer of aluminum  
having a resistivity between about 10 ohms per  
square and about 1700 ohms per square.
- 25
12. The packaging system according to claim 3, wherein:  
the conductive film is a metallized layer of aluminum  
having a resistivity between about 10 ohms per  
square and about 1700 ohms per square.
- 30

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13. The packaging system according to claim 4, wherein:

5           the conductive film is a metallized layer of aluminum  
          having a resistivity between about 0.1 ohms per  
          square and about 2000 ohms per square.

14. The packaging system according to claim 13, wherein:

10           the metallized layer of aluminum has a resistivity  
          greater than about 60 ohms per square.

15. The packaging system according to claim 5, wherein:

15           the conductive film is a metallized layer of aluminum  
          having a resistivity between about 10 ohms per  
          square and about 1700 ohms per square.

20

16. The packaging system according to claim 15, wherein:

          the metallized layer of aluminum has a resistivity  
          between about 10 ohms per square and about 1700  
25           ohms per square.

17. The packaging system according to claim 15, wherein:

30           the metallized layer of aluminum has a resistivity  
          between about 60 ohms per square and about 1650  
          ohms per square.

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18. The packaging system according to claim 6, wherein:

5           the conductive film is a metallized layer of aluminum  
          having a resistivity between about 10 ohms per  
          square and about 1700 ohms per square.

19. The packaging system according to claim 7, wherein:

10           the conductive film is a metallized layer of aluminum  
          having a resistivity between about 10 ohms per  
          square and about 1700 ohms per square.

15 20. A susceptor having variable responsiveness to heating  
    from microwave radiation, comprising:

          (a) a support;

20           (b) a metallized layer formed upon the support, the  
          metallized layer having:

          (1) a first region that is operative to heat in  
          response to microwave radiation;

25           (2) a second region that is operative to heat  
          in response to microwave radiation, the  
          second region having conductivity breaks  
          formed in the metallized layer prior to  
30           microwave irradiation to reduce the second  
          region's responsiveness to microwave  
          radiation; and,

35           (c) the susceptor being adapted to selectively heat  
          the surface of a food substance placed in close  
          proximity thereto during microwave irradiation.

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21. The susceptor according to claim 20, wherein:

the second region is less responsive to microwave radiation than the first region.

5

22. The susceptor according to claim 20, further comprising:

10 (3) a third region of the metallized layer, the third region having conductivity breaks formed in the metallized layer prior to microwave radiation to reduce the third region's responsiveness to microwave radiation.

15

23. The susceptor according to claim 22, wherein:

20 the third region is less responsive to microwave radiation than the second region.

24. The susceptor according to claim 22, wherein:

25 the conductivity breaks in the metallized layer in the third region define a plurality of third subregions each having a surface area;

30 the conductivity breaks in the metallized layer in the second region define a plurality of second subregions each having a surface area; and,

35 the surface area of the individual third subregions being less than the surface area of the individual second subregions.



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25. A method for making one region of a susceptor less responsive to microwave heating, comprising the step of:

5       reducing the responsiveness of a first region of a thin film metallized susceptor to the heating effects of microwave radiation compared with a second region of the thin film metallized susceptor, by disrupting the electrical continuousness of the thin metallized film of  
10       the susceptor over the first region prior to microwave cooking.

15       26. The method according to claim 25, wherein:

      said disrupting comprises cutting the thin metallized film of the susceptor in the first region.

20       27. The method according to claim 26, further comprising the step of:

      scoring the second region of the thin metallized film of the susceptor where the dimension of the  
25       continuous metallized film areas in the second region are larger than the dimensions of the continuous metallized film in the first region.

30       28. The method according to claim 25, wherein:

      said disrupting comprises separating the thin metallized film of the susceptor in the first region into a plurality of distinct subregions of  
35       continuous metallized film, where the individual subregions in the first region have a surface

-38-

area less than the surface area of the second region.

- 5 29. A method of making regions of a susceptor selectively responsive to microwave heating, comprising the step of:

10 detuning a region of a susceptor by disrupting the continuity of the thin metallized film of the susceptor in said region prior to microwave cooking so that the responsiveness of said region to the heating effects of microwave radiation is changed.

- 15 30. A packaging system including susceptor heating means having selective responsiveness to microwave radiation, comprising:

20 a susceptor for heating in response to microwave radiation, the susceptor being adapted to brown or crisp the surface of a food substance placed in close proximity thereto, the susceptor having a susceptor surface that heats when  
25 exposed to microwave radiation, the susceptor having regions of different responsiveness to microwave radiation achieved by disruptions in the susceptor surface, said disruptions affecting the heating response to a region to  
30 microwave radiation.

31. The packaging system according to claim 30, wherein:

35 a first region of the susceptor comprises small discrete areas defined by the disruptions in the

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5           susceptor surface, the small discrete areas having dimensions small enough to reduce the responsiveness of the first region to heating by microwave irradiation relative to said second region.

32. The packaging system according to claim 30, wherein:

10           the first region of the susceptor comprises a plurality of substantially rectangular shaped susceptor surface areas defined by said disruptions in the susceptor surface.

15

33. A susceptor means having a target area of intensified heating when exposed to microwave heating, comprising:

20           a susceptor surface which heats when exposed to microwave radiation, the susceptor surface having two regions:

25           (a) a directed flow region having a plurality of strips defined by disruptions in the susceptor surface, the strips extending toward a target region; and,

30           (b) a target region, the heating effect of the target region being intensified when exposed to microwave radiation as compared to an uncut susceptor.

34. A susceptor means having a target area of intensified heating when exposed to microwave heating, comprising:

35

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a susceptor surface which heats when exposed to microwave radiation, the susceptor surface having two regions:

- 5 (a) a directed flow region having a spiral strip defined by a disruption in the susceptor surface, the spiral strip extending toward a target region; and,
- 10 (b) a target region, the heating effect of the target region being intensified when exposed to microwave radiation as compared to an uncut susceptor.

15

35. A method of making a selected region of a susceptor less responsive to microwave heating, comprising the step of:

- 20 disrupting the susceptor surface in a selected region sufficiently to introduce an additional significant capacitive component to the impedance of the susceptor in the selected region, thereby resulting in a disrupted region
- 25 which is less than the total area of the susceptor surface and which is less responsive to the heating effects of microwave radiation.

- 30 36. A susceptor having a plurality of regions, where one region has reduced responsiveness to microwave heating, comprising:

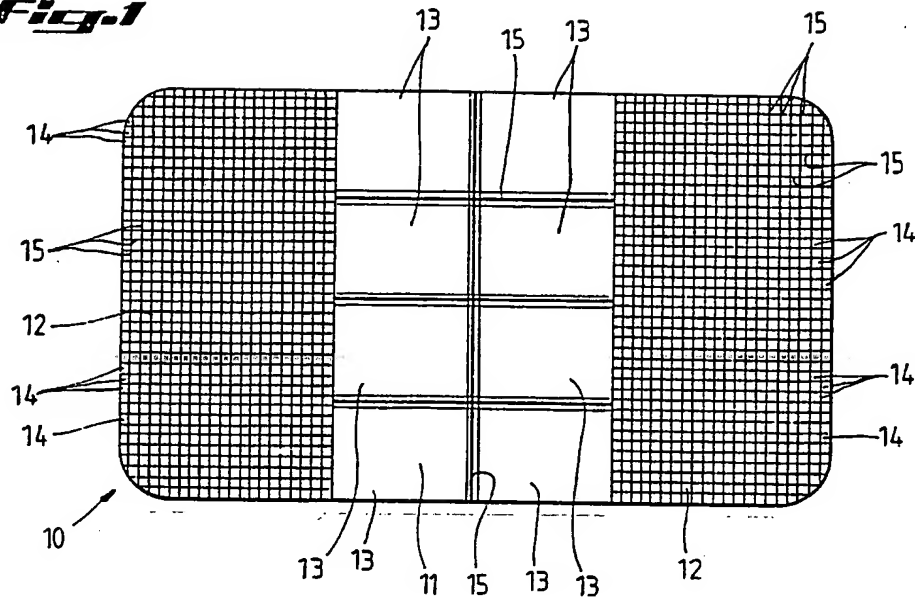
- 35 a first region of the susceptor surface which heats responsive to microwave radiation; and,

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5 a second region of the susceptor surface, the second region having a disrupted susceptor surface, the second region having an additional significant additional capacitive component in the impedance of the susceptor, the second region being less responsive to the heating effects of microwave radiation.

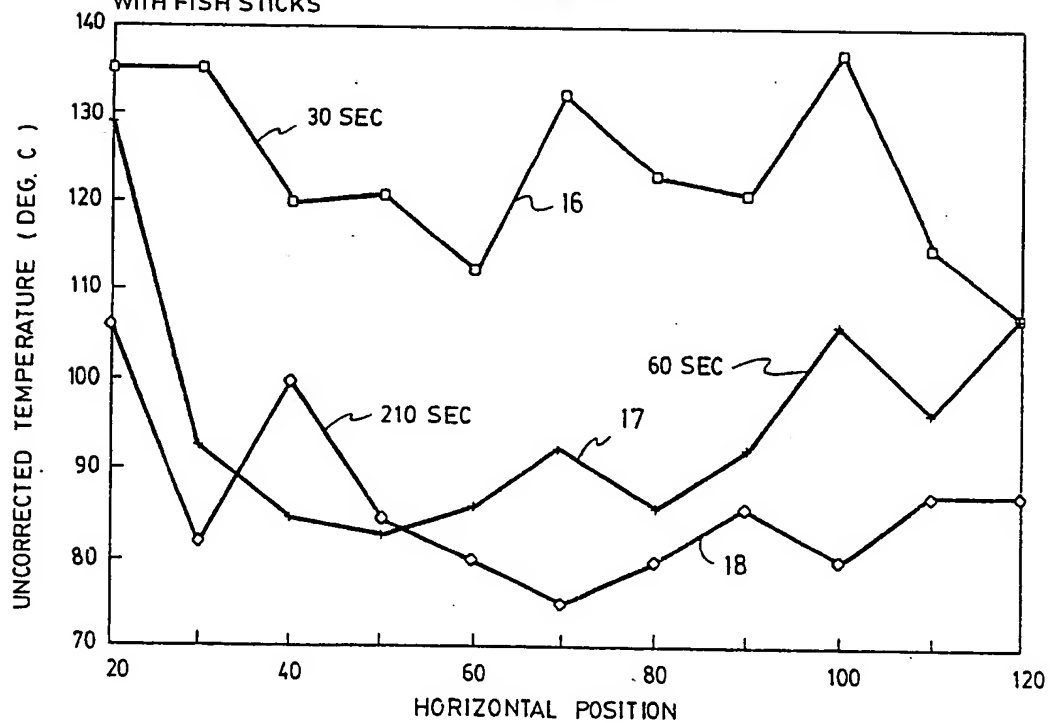
1 / 15

**Fig. 1**



HEATING PROFILE OF  
STD. FISH SUSCEPTOR  
WITH FISH STICKS

**Fig. 2**

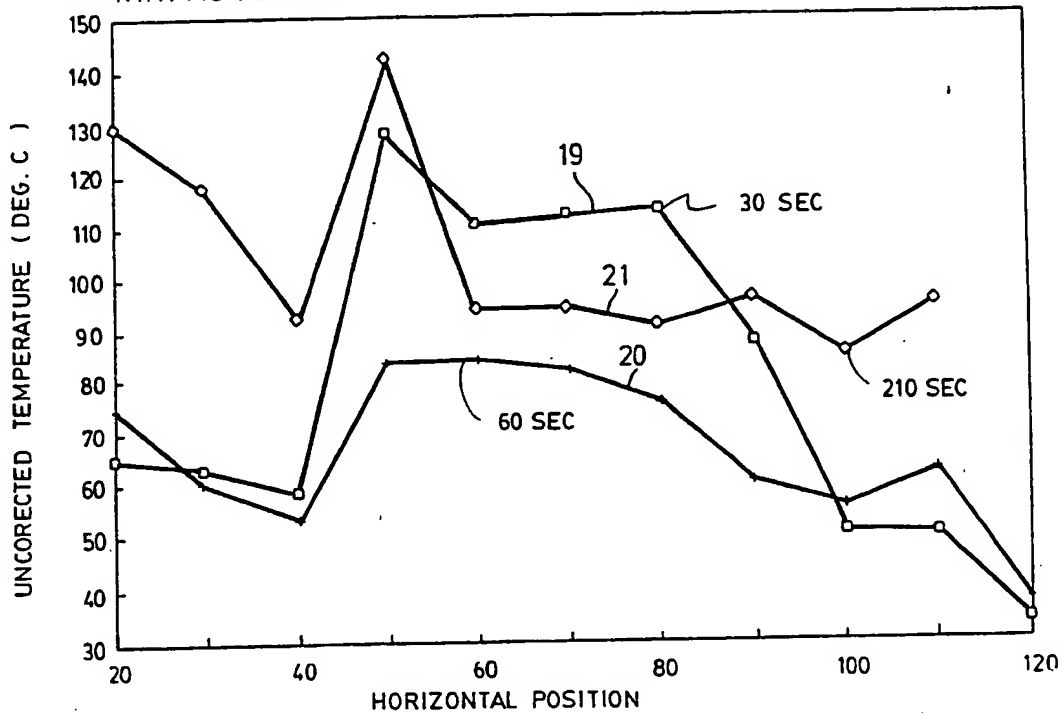


SUBSTITUTE SHEET

TEMP. PROFILE OF  
SCORED FISH SUSCEPTOR  
WITH FISH STICKS

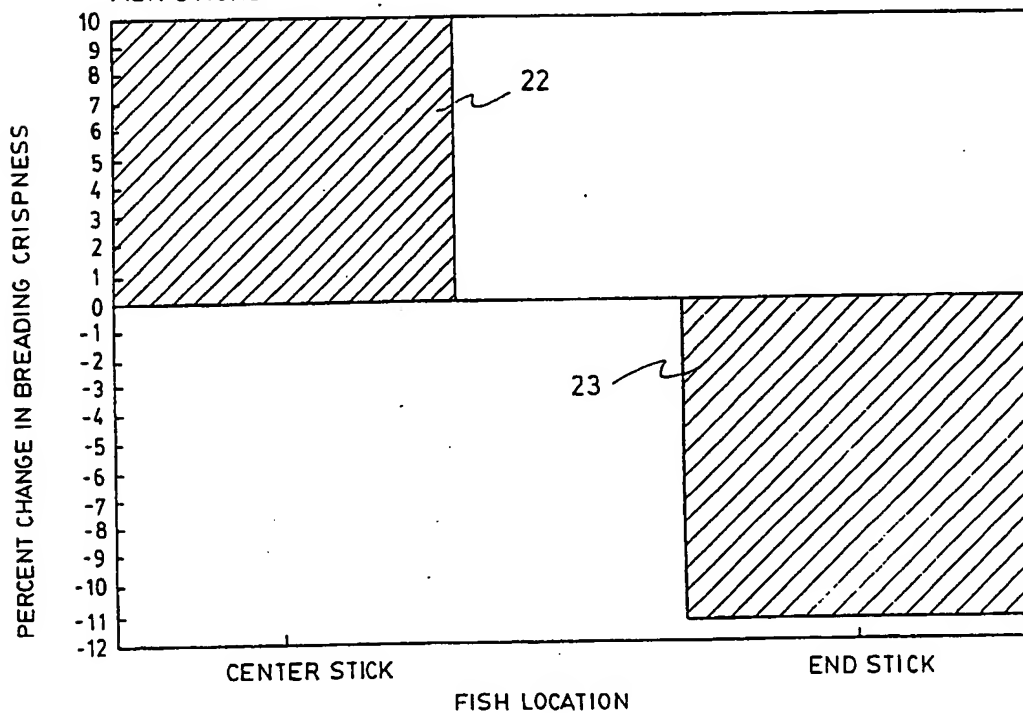
2/15

**Fig.3**



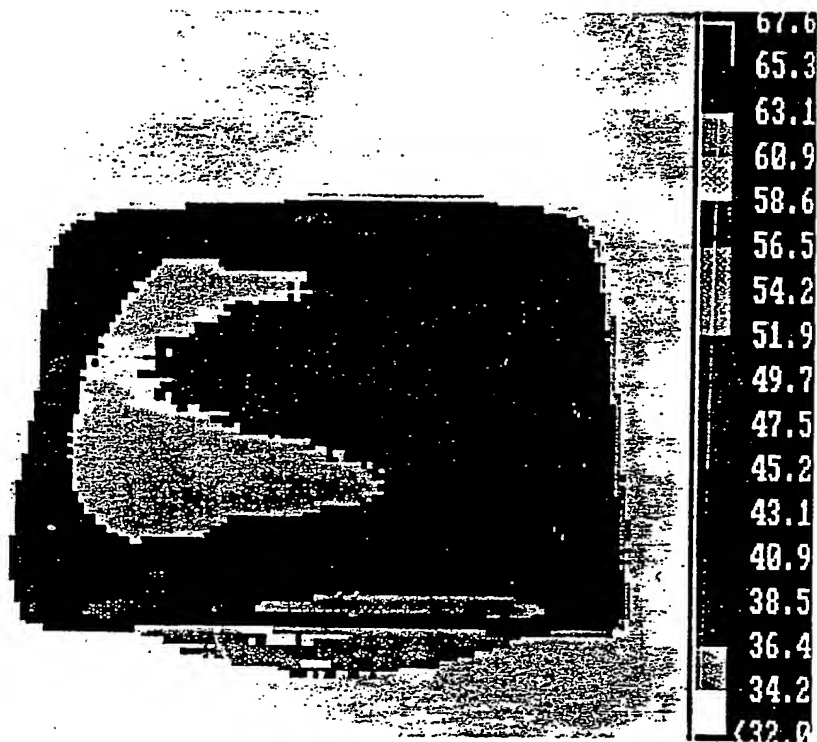
EFFECT OF SCORED  
SUSCEPTOR ON CRISPNESS  
FISH STICKS

**Fig.4**

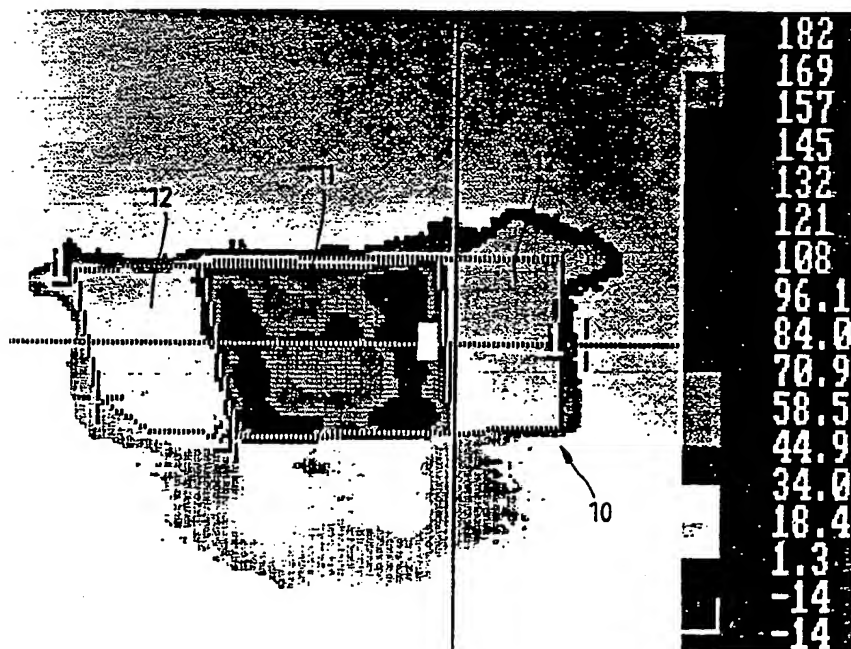


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**Fig. 6**

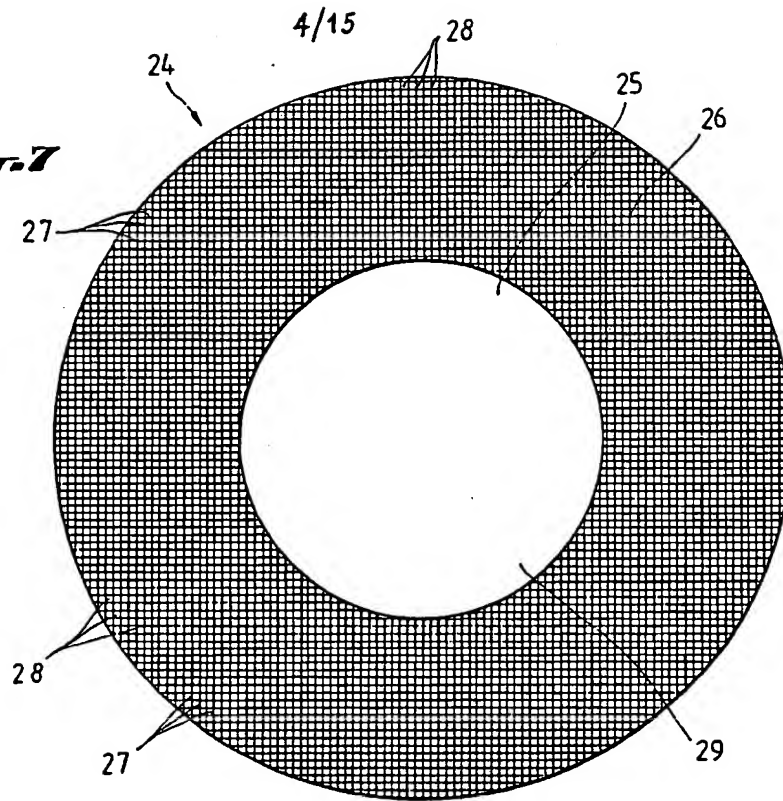


**Fig. 5**



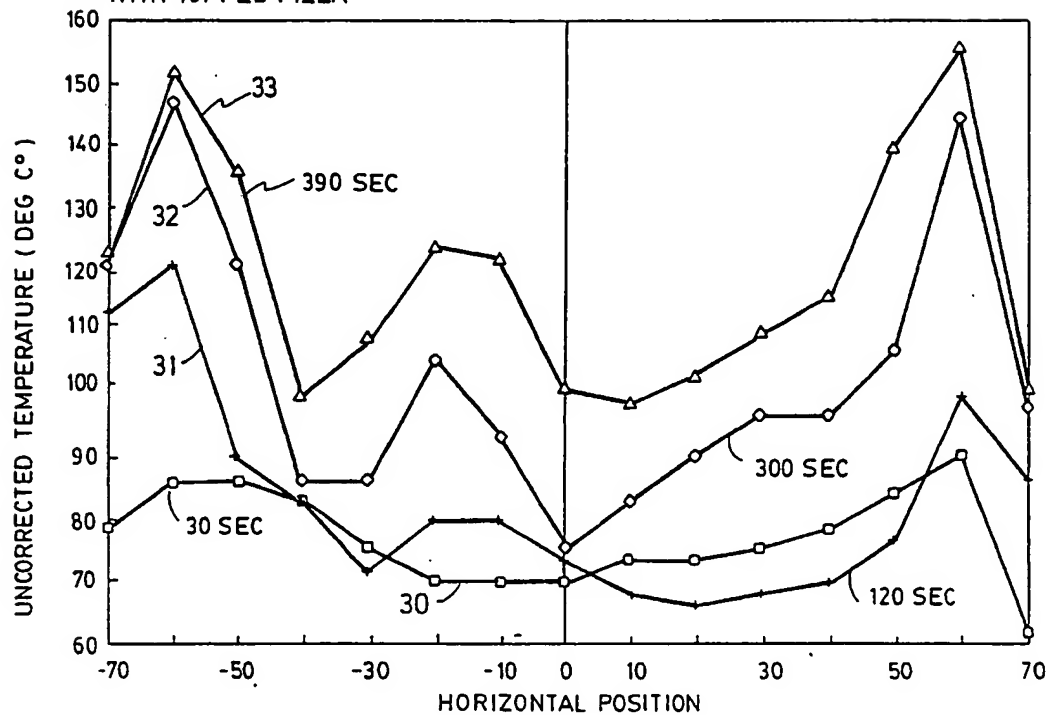


**Fig. 7**



**Fig. 8**

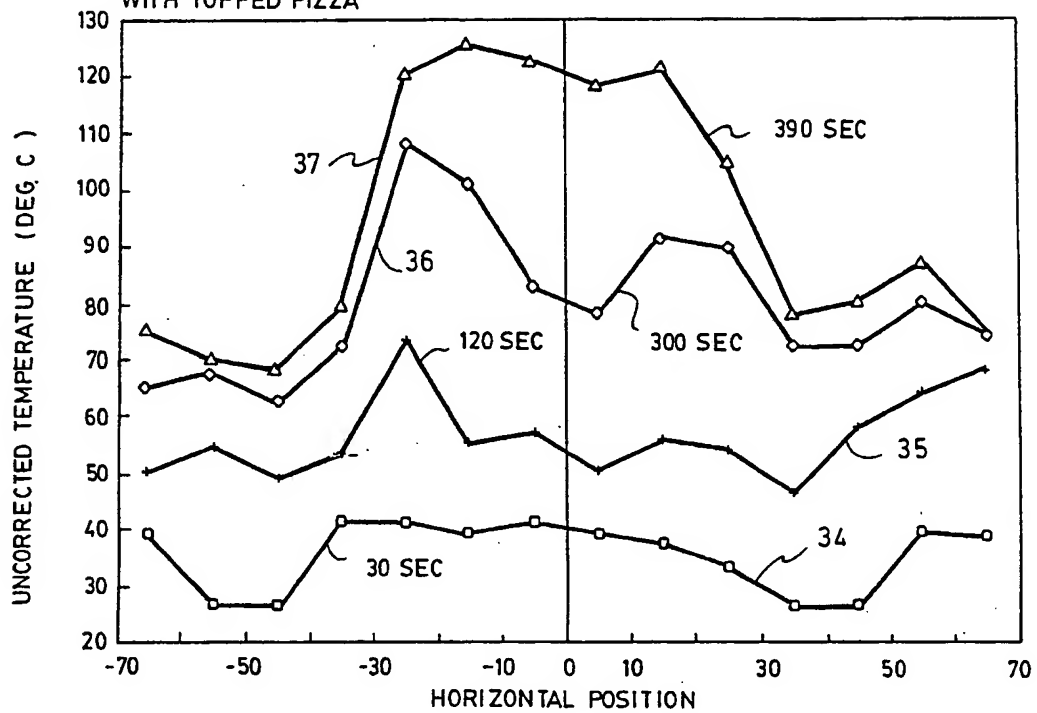
TEMPERATURE PROFILE OF  
STD. PIZZA SUSCEPTOR  
WITH TOPPED PIZZA



5/15

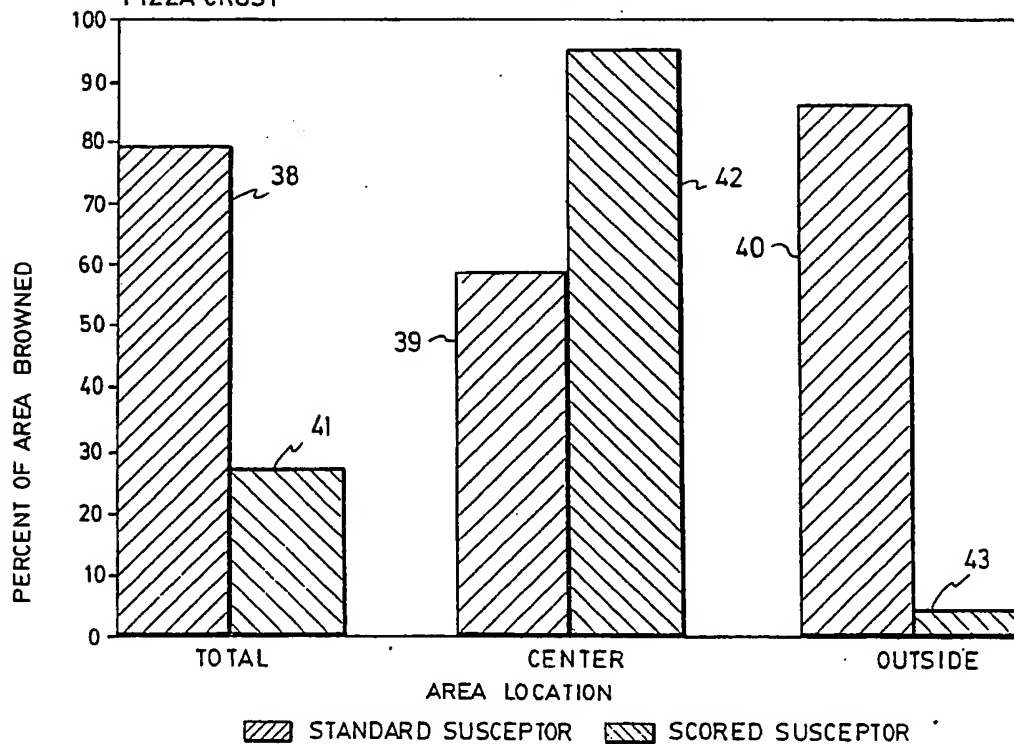
TEMP. PROFILE OF  
SCORED PIZZA SUSCEPTOR  
WITH TOPPED PIZZA

**Fig.9**

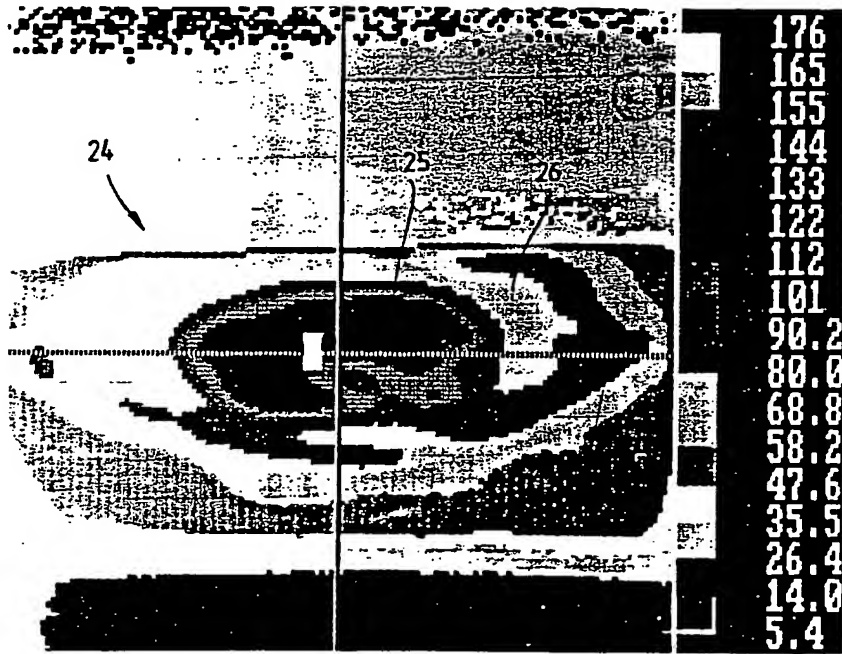
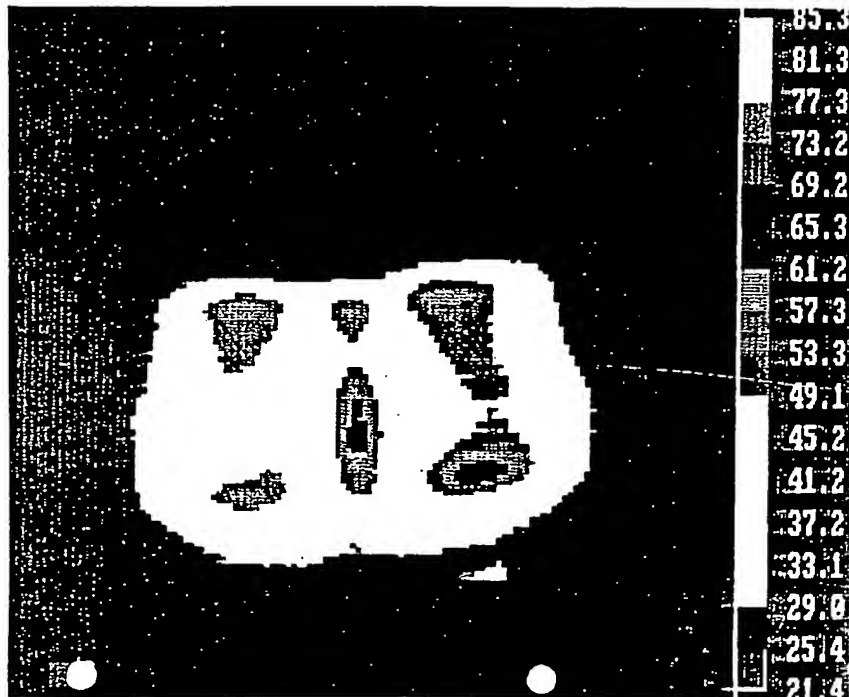


EFFECT OF SUSCEPTOR  
TYPE ON BROWNING  
PIZZA CRUST

**Fig.10**

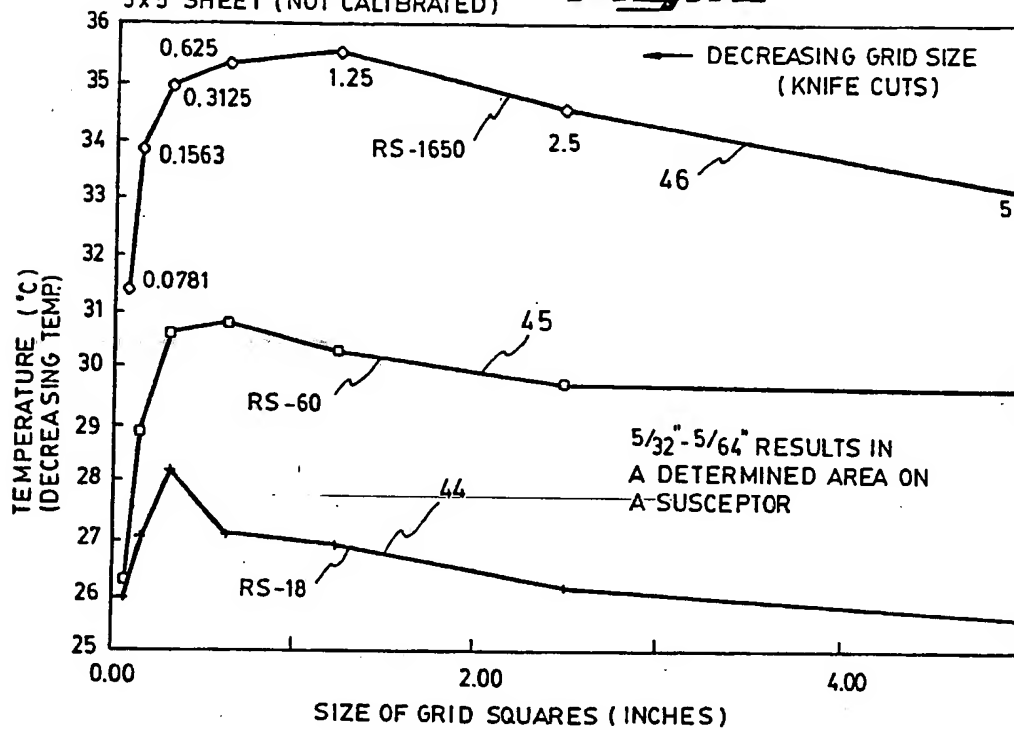
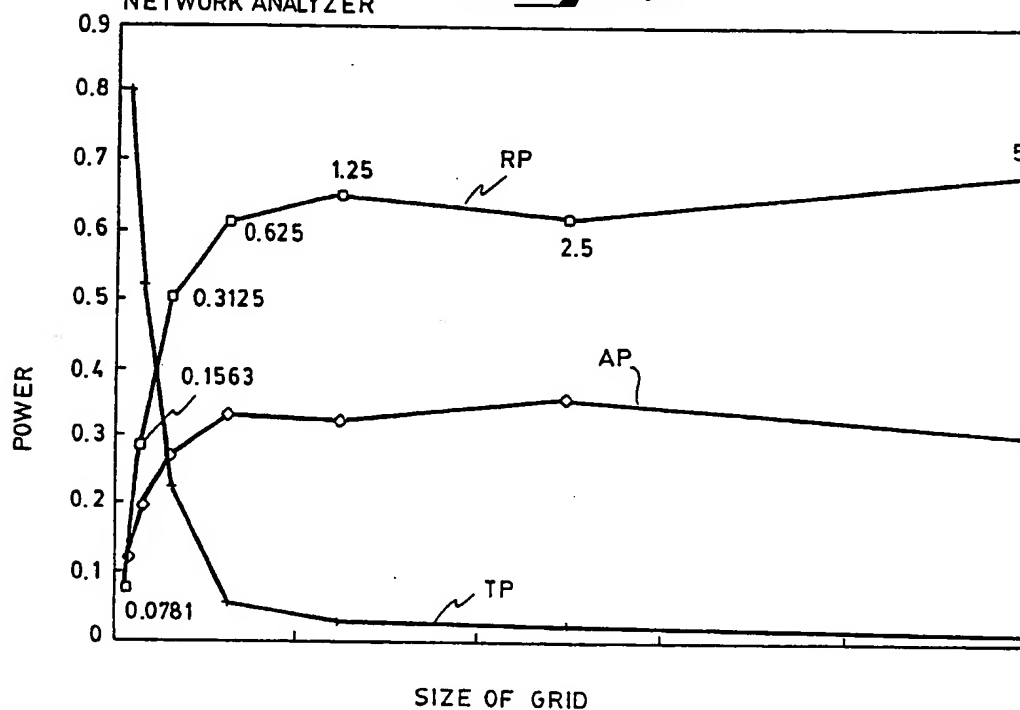


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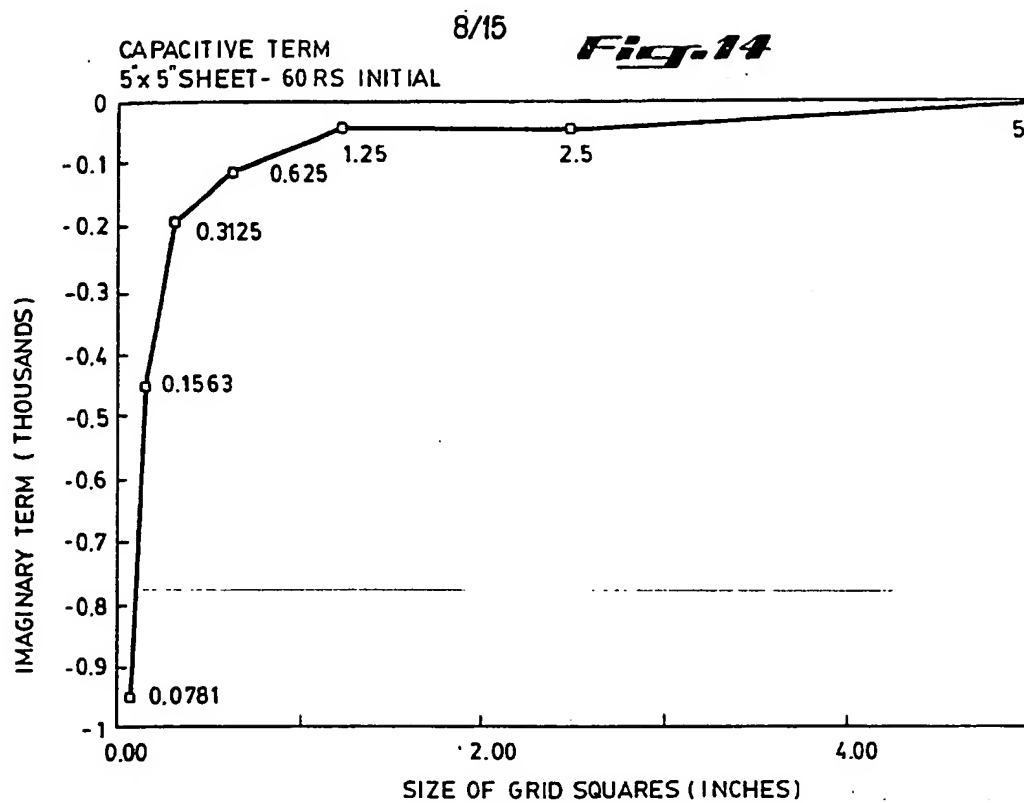
**Fig. 11****Fig. 25**

SUBSTITUTE SHEET

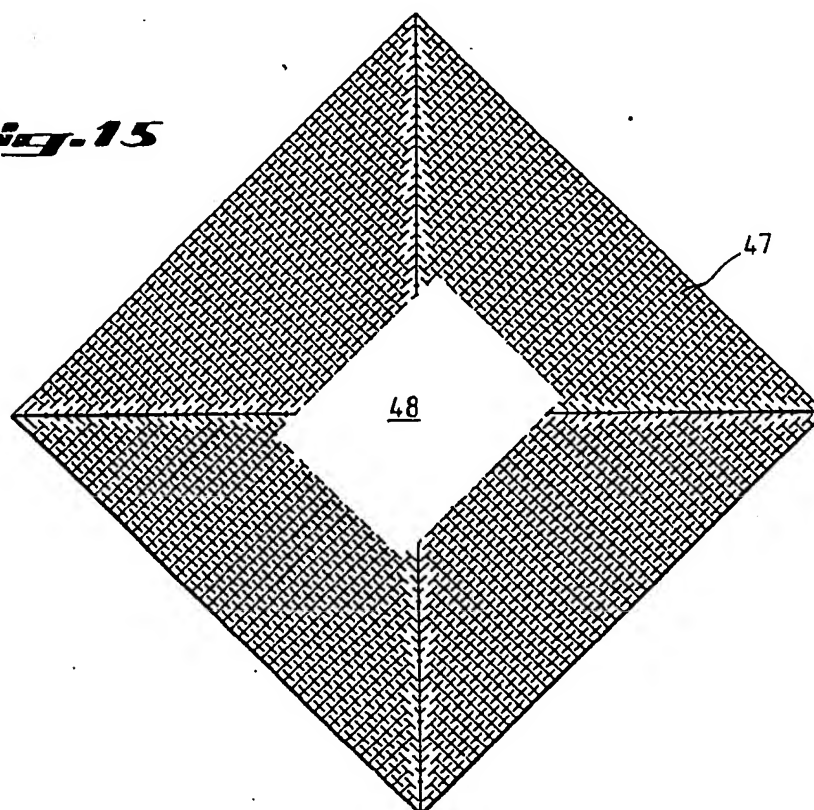
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MEAN IR TEMPERATURES  
5"x5" SHEET (NOT CALIBRATED)**Fig. 12**CUT GRID VS POWER  
NETWORK ANALYZER**Fig. 13**

SUBSTITUTE SHEET

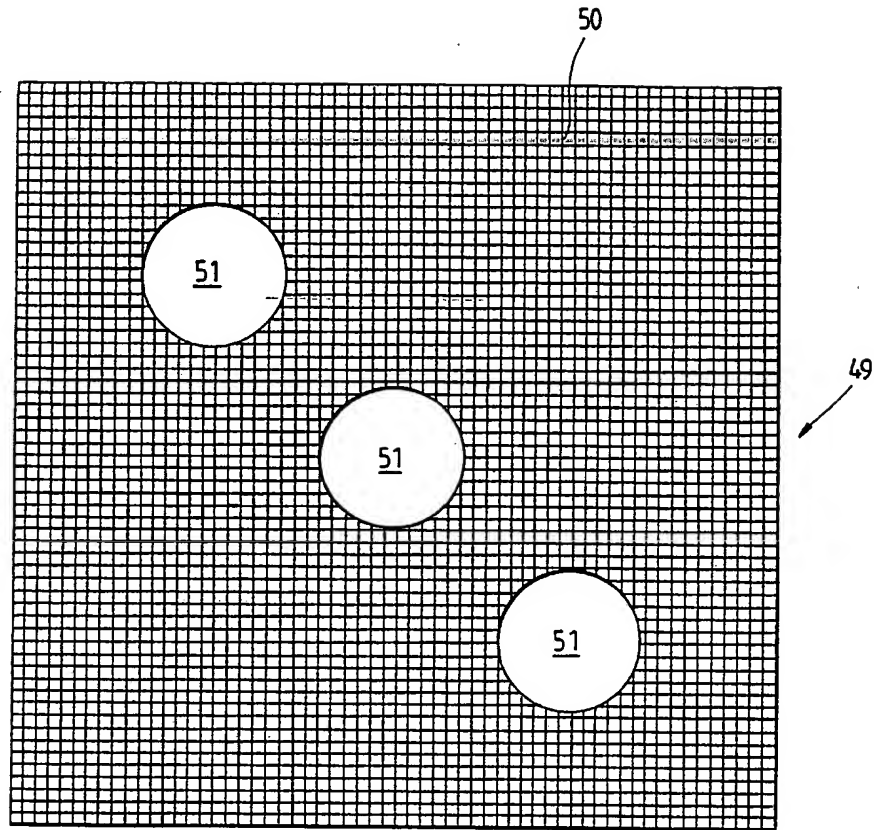


**Fig. 15**



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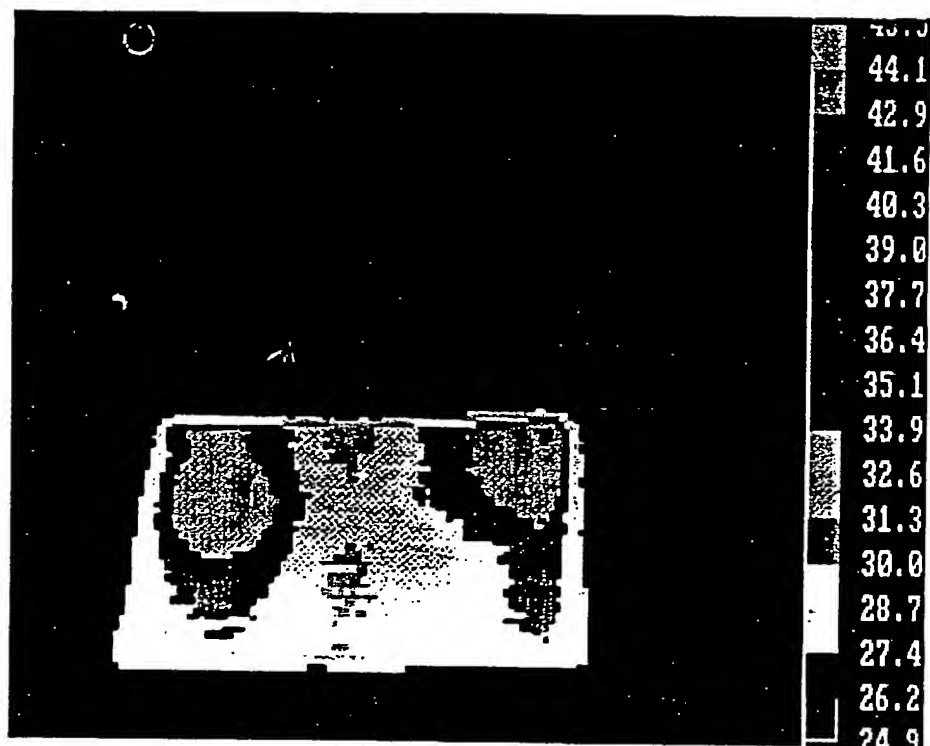
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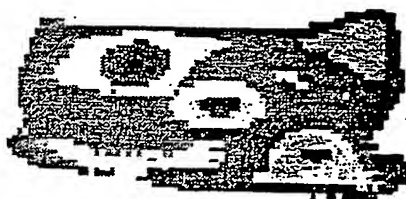
**Fig. 16**

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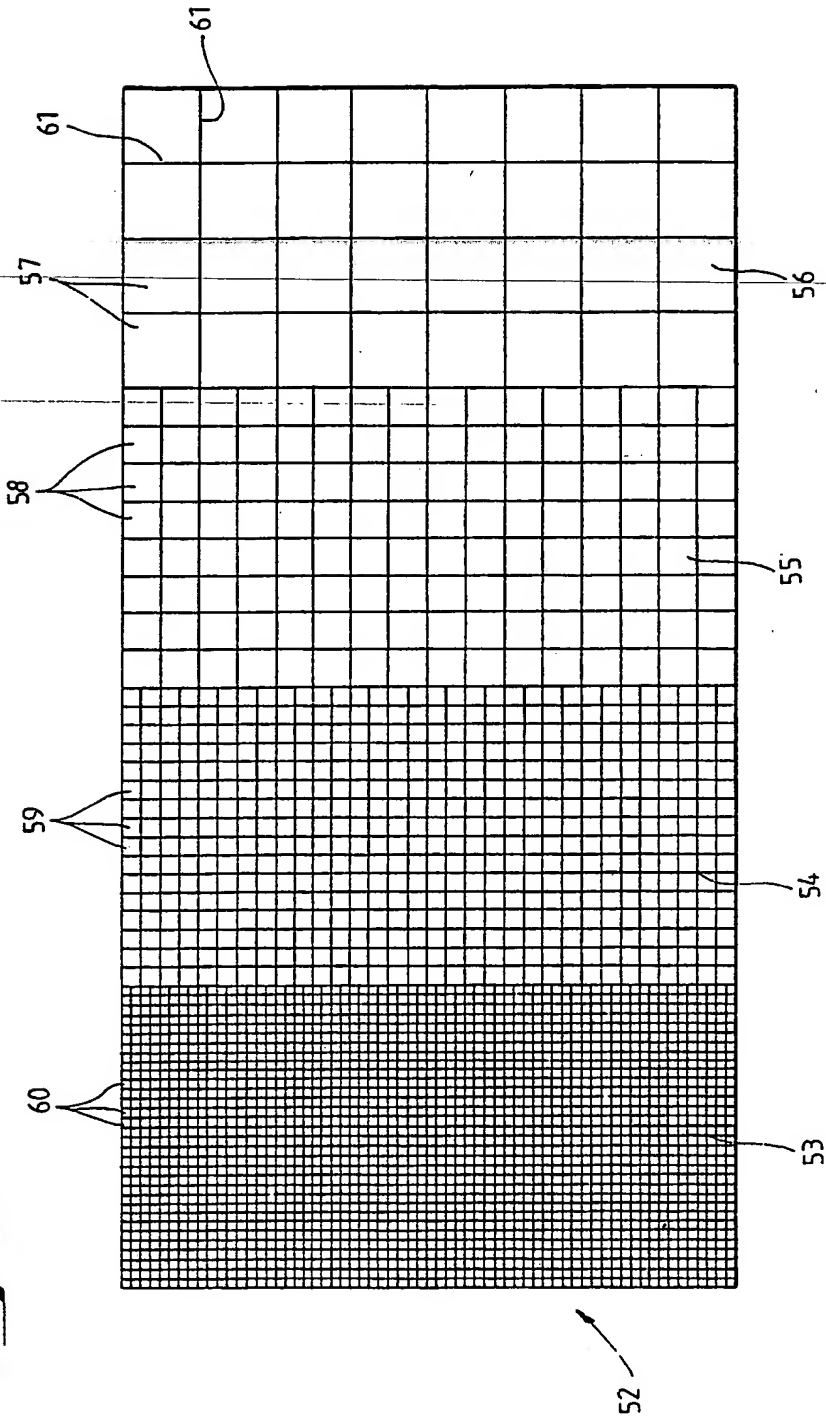
**Fig. 17**



**Fig. 18**



**Fig. 19**





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DISTANCE VS. TEMPERATURE  
SUSCEPTOR GRADIENT

Fig. 20

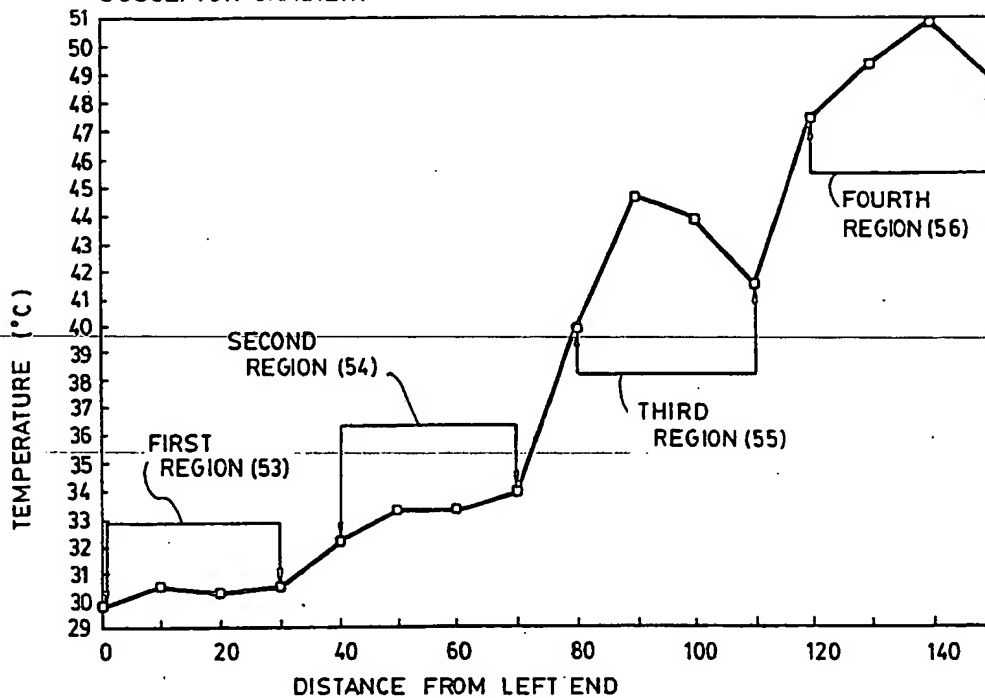


Fig. 21

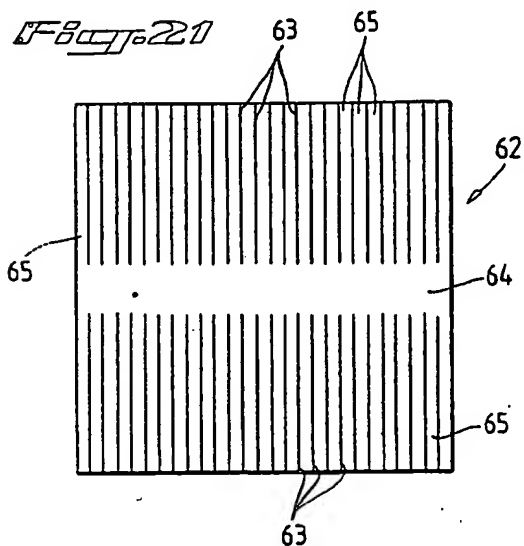
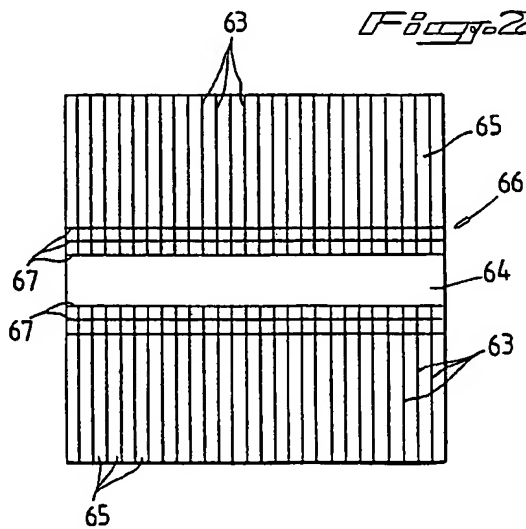
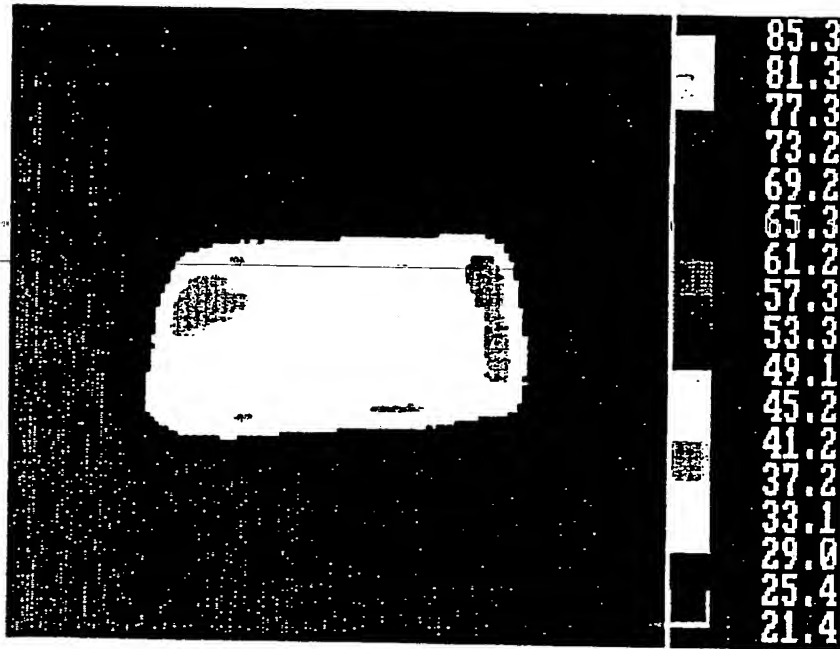


Fig. 22

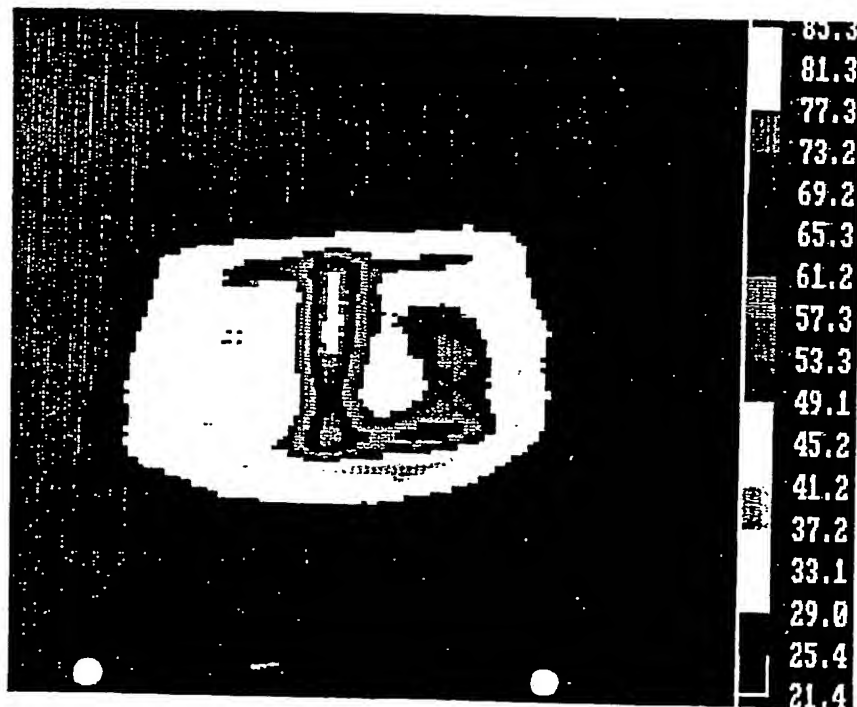


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**Fig. 22**

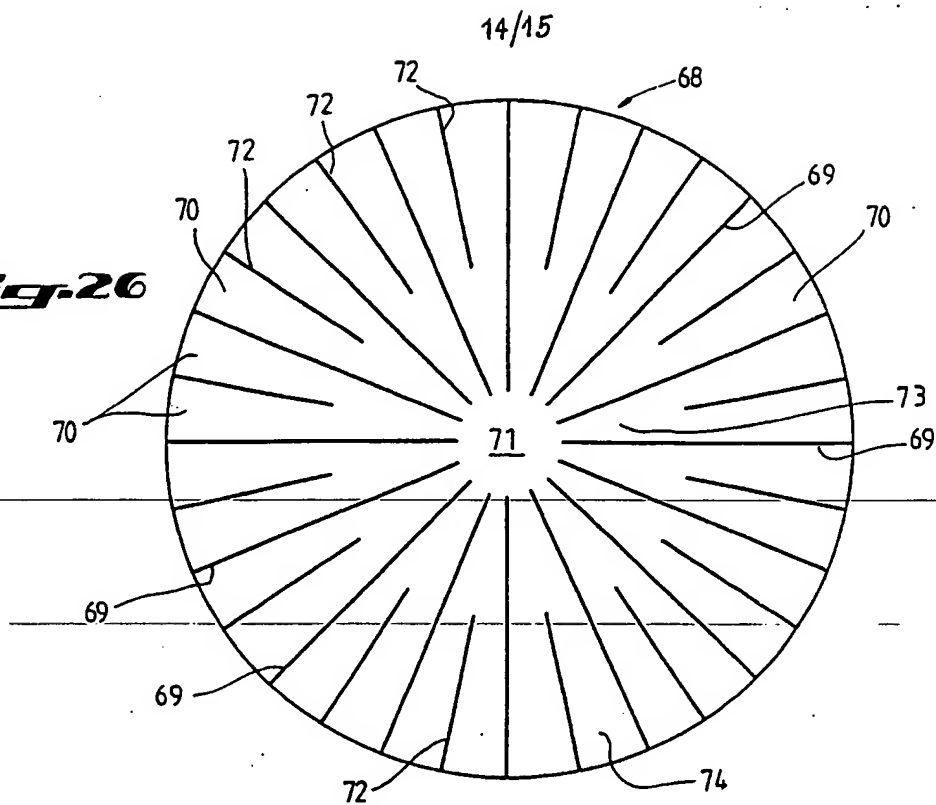


**Fig. 23**

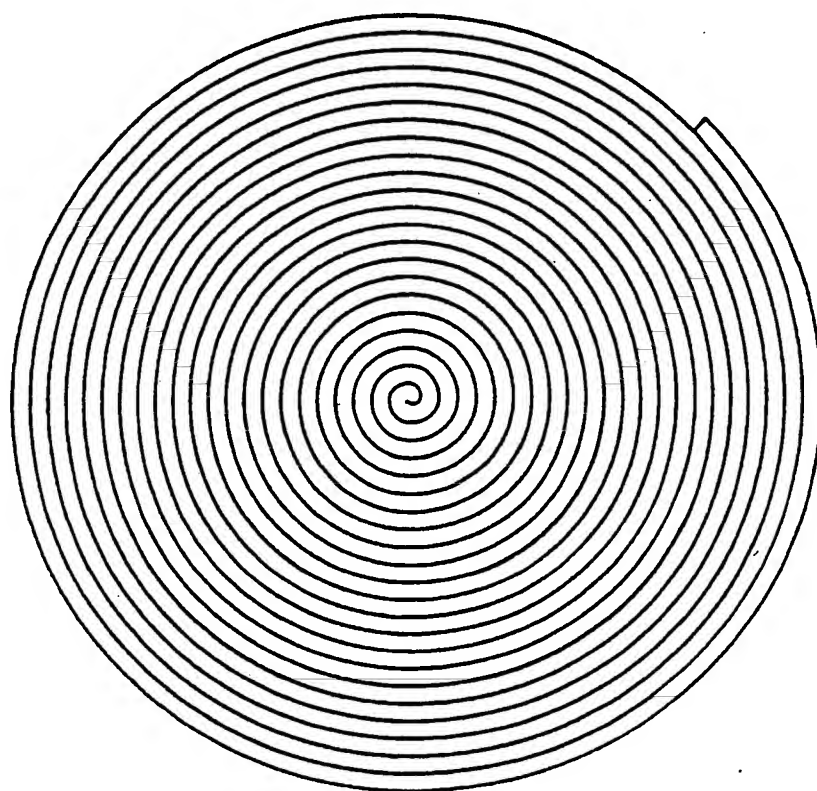


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**Fig. 26**

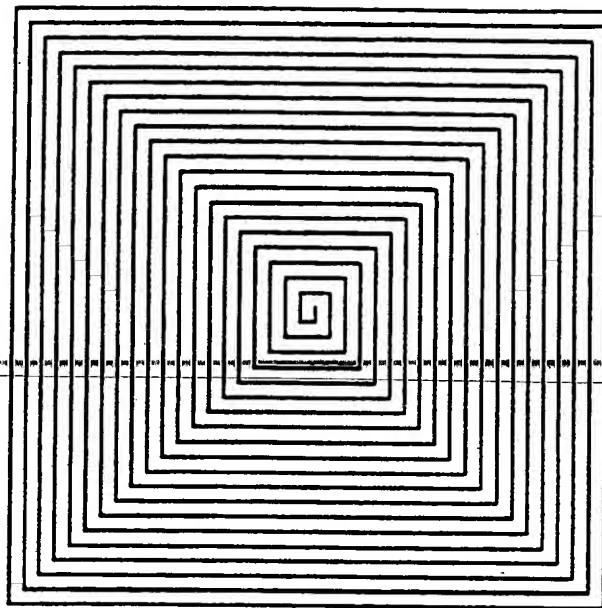


**Fig. 27**

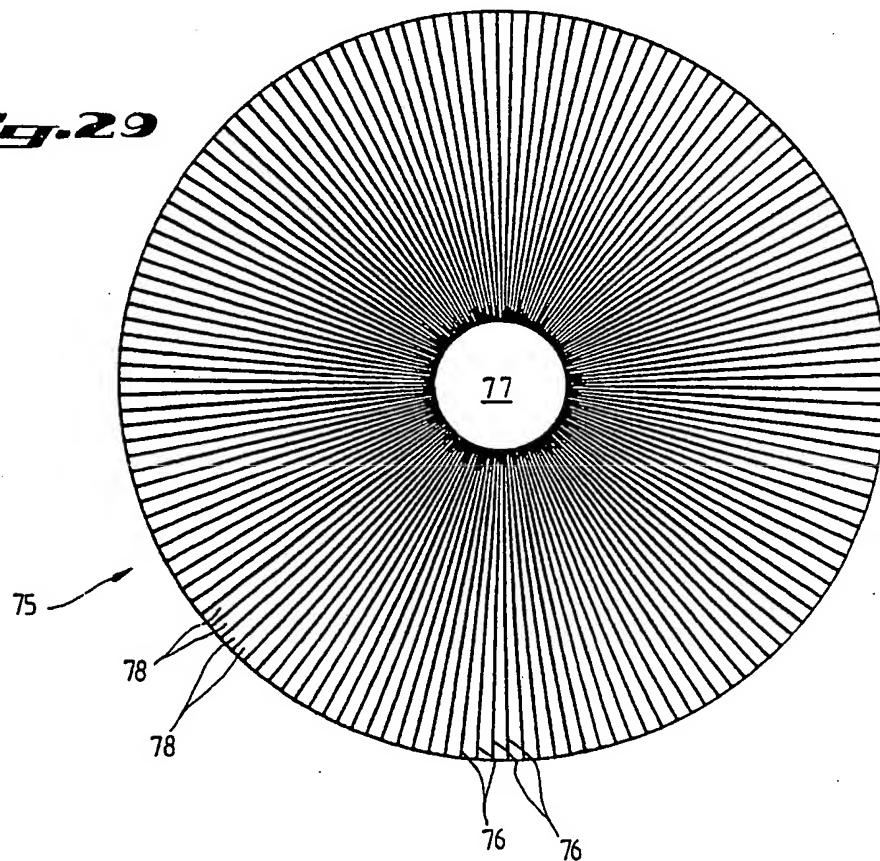


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**Fig.28**



**Fig.29**




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## INTERNATIONAL SEARCH REPORT

PCT/US 89/02239

International Application No

<b>I. CLASSIFICATION OF SUBJECT MATTER</b> (If several classification symbols apply, indicate all) <sup>6</sup>		
According to International Patent Classification (IPC) or to both National Classification and IPC		
Int.Cl. 4 H05B6/64		
<b>II. FIELDS SEARCHED</b>		
Minimum Documentation Searched <sup>7</sup>		
Classification System	Classification Symbols	
Int.Cl. 4	H05B	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched <sup>8</sup>		
<b>III. DOCUMENTS CONSIDERED TO BE RELEVANT<sup>9</sup></b>		
Category <sup>10</sup>	Citation of Document, <sup>11</sup> with indication, where appropriate, of the relevant passages <sup>12</sup>	Relevant to Claim No. <sup>13</sup>
A	US,A,3219460 (E. BROWN) 20 November 1962 see column 2, line 24 - column 3, line 31; - figures 2-4 ---	1-3, 8, 20-36
A	US,A,3302632 (E.C. FICHTNER) 06 December 1963 see column 2, line 6 - column 3, line 3; figures 1-4 ---	1-3, 8, 20-36
A	US,A,4676857 (SCHARR ET AL.) 30 June 1987 see column 6, line 15 - column 7, line 5; figures 6-8b ---	1, 2, 20, 30
A	EP,A,206811 (ALCAN INTERNATIONAL LIMITED) 30 December 1986 see page 18, line 21 - page 19, line 11; figures 10a-10b ---	1, 2, 20, 30
-/--		
<p><sup>10</sup> Special categories of cited documents:</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"T" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> <p>"I" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"&amp;" document member of the same patent family</p>		
<b>IV. CERTIFICATION</b>		
Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report	
28 SEPTEMBER 1989	- 2 NOV 1989	
International Searching Authority	Signature of Authorized Officer	
EUROPEAN PATENT OFFICE	RAUSCH R.G. 	

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)		
Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.
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A	US,A,3394007 (RICHARD LINCOLN CAMPBELL) 23 July 1968 ---	
A	US,A,3547661 (PETER N. STEVENSON) 15 December 1970 ---	
A	FR,A,2382878 (NIPPON ELECTRIC GLASS COMPANY, LIMITED ET AL.) 06 October 1978 ---	
A	US,A,4495392 (DERBY) 22 January 1985 ---	

**ANNEX TO THE INTERNATIONAL SEARCH REPORT  
ON INTERNATIONAL PATENT APPLICATION NO.**

PCT/US 89/02239

SA 29084

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.  
The members are as contained in the European Patent Office EDP file on  
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28/09/89

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US-A-3302632		None	
US-A-4676857	30-06-87	None	
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US-A-3547661	15-12-70	None	
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